THE SIGNIFICANCE OF DELAYED REACTIONS IN YOUNG CHILDREN

BY

MAGDA SKALET

A DISSERTATION

SUBMITTED TO THE BOARD OF UNIVERSITY STUDIES OF THE JOHNS HOPKINS UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

1930

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I. HISTORICAL SUMMARY OF THE LITERATURE

Introduction. Before commencing a discussion of the experimental methods and the results of the present investigation of delayed reactions in young children, a critical survey will be given of the experimental literature pertaining to the processes involved in these reactions. A delayed response is one in which the determining stimulus is absent at the moment of response. The essential part of the situation is that memory of some particular part of the stimulus pattern is necessary for a correct response when the original determining stimulus is absent. Not only memory, but attention, learning, and perception of form and location are inextricably involved in the test situations formulated by the investigators in this field. There is marked disagreement among these authors as to the nature of the representative

factors that act in place of the original stimulus and in analyzing the various processes included. Very few of them recognize the multiplicity of elements in a single delayed response.

Animal experimentation. For comparative purposes, a summary of the quantitative results of the investigations on delayed

TABLE 1

The length of delay obtained with various animals

SUBJECTS	NUMBER	DELAY	NUMBER OF ALTERNATIVES	BODILY ORIENTATION	EXPERIMENTER
Rats	1	15 seconds	3	With	Hunter (8)
	12	40 seconds	3	With	Ulrich (18)
Cats	8	18 seconds	2	With	Yarbrough (21)
	1	30 seconds	2	Without	Cowan (5)
	8	4 seconds	3	With	Yarbrough (21)
	2	16 hours	4	Without	Adams (1)
Dogs	2	5 minutes	3	With	Hunter (8)
	2	1 minute	4	Without	Ulrich (18)
Raccoons	4	25 seconds	3	Without	Hunter (8)
Monkeys	4	15–20 hours	2	Without	Tinklepaugh (17)
	2	56 seconds	3	Without	Rugh (25)
Chimpanzees	1	15 seconds	?	Without	Kohts (16)
	2	16½ hours	Buried food	Without	Köhler (13)
	4	48 hours	Buried food	Without	Yerkes and Yerkes (25)
	4	4 hours	4	Without	Yerkes and Yerkes (25)
Gorilla	1	?	5	Without	Yerkes (22)
	1	48 hours	Buried food	Without	Yerkes (23)
	1	3 hours	4	Without	Yerkes (23)
	1	10 minutes	6	Without	Yerkes (24)

reactions in animals reported in this chapter is given in table 1. A large portion of this table is taken directly from Tinklepaugh (17), and the remainder from the original reports not given in this article. The number and kinds of subjects employed, the maximum length of delay for securing accurate responses, the

number of alternatives offered, the presence or absence of bodily orientation, and the name of the experimenter are included in the table. It must be remembered when referring to this table, that the length of delay possible with one experimental method is not comparable to that obtained by another method. Many of the investigators do not state that the delay obtained is the maximum for that animal with the type of situation used, but do set forth the maximum periods of delay obtained in the reported experiments.

Since Hunter (7) formulated and conducted the first extensive experiments on delayed reactions, and since these served as a pattern for the majority of the later research, his procedure and results will be reviewed in some detail. He attempted to discover how long after the determining stimulus had disappeared the subjects could wait and still react correctly, and to analyze their typical behavior in solving the problem.

Hunter's subjects consisted of 22 rats, 2 dogs, 4 raccoons, and 5 children who were from two and one-half to eight years of age. The light boxes developed for the experiments were essentially the same for all three kinds of animals included, differing only in absolute dimensions. The children were tested in a suitably arranged room instead of a box-like apparatus. Before the animals used could respond accurately, Hunter found it necessary to give them a training series. The food-light box association was learned, then several succeeding trials were given in which the light was turned off before the animal was released from the confining compartment.

According to Hunter, this apparatus and procedure has all the necessary features for the measurement of delayed reactions, for it is adapted to the subjects, it provides a means for presenting the stimulus in one of several places which are equally accessible, and no differential cues can be presented to the subject during the period of delay.

White rats succeeded in running in the proper direction when the delay between the disappearance of the light and their release was not more than 10 seconds, but only in case they maintained their orientation towards the light during the interval. Rac-

coons, on the other hand, although they could not go in the right direction if more than 25 seconds had elapsed since the light was turned off, succeeded in this interval whether they did or did not change the positions of their bodies. Dogs could make accurate responses after an interval of five minutes when they retained their positions with respect to the stimulus shown.

Watson (20) criticizes Hunter for inadequate control of the situations in these experiments. He asserts that cues given by the experimenter, perception of temperature differences in the most recently lighted box, the odors of food, and certain visual effects of the light might plausibly lead to the correct response. Hunter (8) refutes each of these possibilities by pointing out the results obtained in control experiments, and from the observations of the animals during the delay intervals.

Hunter's results (7) indicate that the following factors influence the maximal period of delay: different groups of animals, the size of the release, and the number of light boxes used. He concludes that punishment and reward, the number of trials daily, and the varying brightnesses of the different backgrounds do not materially affect the amounts of the delay. The correct response occurs because the residual effects of the sensory stimuli are retained and are subsequently re-aroused. The selective revival of these stimuli functions as a necessary substitute for a definite component of the objective stimulus aspect of the problem.

Several investigators have used apparatus constructed according to Hunter's design. Ulrich (18) studied the posturing of rats in connection with delayed response. He found that there was a definite direction in the rat's progress only when there was orientation, a series of forward movements, or scratching at a certain part of the retaining chamber. His rats responded correctly after an interval of 40 seconds. It has been shown by Yarborough (21) that cats also depended for success in responding to light and sound stimuli, upon the maintenance of a fairly constant bodily orientation during the delay interval. The maximum interval obtained giving a correct response was 18 seconds with the use of two alternatives, and 4 seconds when three were

employed. Walton (19) secured correct reactions from dogs in two-thirds of the trials using four compartments and a delay of one minute during which the cage containing the dog was turned through 90 degrees; thereby, totally disturbing the dog's position in the cage. When two compartments were used, considerably longer delays were possible, and although various disturbing olfactory, visual, and auditory stimuli were introduced during the delay period, they produced little effect. Rugh (16) obtained a maximum delay of 56 seconds with two monkeys; above this point the responses were purely chance.

The chief criticism of Hunter's method and its modifications as given by Buytendijk (4), Köhler (11), and Tinklepaugh (17), is that the experiments require for their solution, superficial accustoming and experience on the part of the subjects, since they do not afford any natural connections comprehensible to the animals. According to these authors, this apparatus is not adequately adapted to the subjects. Several experimental situations have been set up differing from that used by Hunter (7) with the animals in that the primary motivational control was more direct.

Yerkes (22) placed five brass boxes, two inches apart on a board, equipped with hinges so that they could be thrown back, and provided them with electrical connections for giving a shock if this was desired. In none of the 15 trials when the food was placed in one of these boxes did the gorilla make a correct first response after a one minute delay. In an attempt to train the gorilla always to choose the middle object, 80 trials were insufficient for her to achieve the idea of middleness. A satisfactory response in this case would involve both memory and learning. Yerkes concludes from these data that he evidently failed to properly relate and control reward and punishment and thus discouraged the subject, but the experiments demonstrate the applicability of electrical stimulation for supplying negative motivation to the gorilla.

Due to the inadequacy of this procedure, while working with this same gorilla the next year, Yerkes (23) arranged four boxes (white, red, black, and green, with closely fitting but unhinged

lids) around a mooring post. When one of these four boxes was baited with food, the gorilla attained an accurate response after an interval of three hours without maintenance of orientation. From the control experiments that were carried out, it was ascertained that odors of the food, peculiarities in the appearance of the correct box aside from the color and location, and cues derived from the experimenter did not act as a basis for the gorilla's choice. Yerkes said that the gorilla did not depend upon secondary cues for a correct response; instead the food-box situation, as originally experienced persisted in some manner until the moment of response. The author did not attempt to determine the temporal span of memory accurately or to establish an extreme limit. With practice, the gorilla would probably have made adaptive responses after much longer than three hours, as obtained at this time.

In their experiments with the chimpanzees, Yerkes and Yerkes (25) placed food in one of four boxes similar to those used with the gorilla and these chimpanzees were able to make successful responses to position after 48 hours. The situation in which color was the differentiating factor was very difficult for them, although successful responses were made in delays up to 30 minutes. As with the gorilla, all the experiments conducted to see whether or not success was furthered by secondary cues such as odor of the food, position at release or the behavior of the experimenter yielded negative results.

The experience of eating the food was measurably more effective in determining a subsequent delayed reaction than was the experience of seeing the food deposited in a certain place. Fifty-eight per cent of the incorrect choices were the boxes in which the food had been obtained in the previous trial. Recognizing this tendency to perseverational response, Yerkes and Yerkes (25) plan to formulate a method for determining the relative mnemonic value of seeing a box baited and the experience of obtaining food from a given box, so that the trials can be properly spaced and thus avoid the conflict between the two factors.

A somewhat different method was used by Yerkes (24) with the gorilla. In this experiment, a turntable mechanism carried an

array of closed food receptacles or cans which differed in color, size, surface pattern, or all of them. The gorilla observed a supply of food placed in one of the cans while it was in a standardized position in front of the cage. Thereupon, the experimenter rotated the table from 90 to 270 degrees, and after interposing a predetermined period of delay, during which the gorilla could busy herself as she chose in the cage, permitted her to come to the grill, and by reaching through endeavor to reinstate the can containing the food, and obtain the reward by appropriately rotating the table. Positive results were obtained after delays of 10 minutes although an attempt was not made to determine the temporal limit for this variety of adaptation.

Tinklepaugh (17) in his investigation, although utilizing the delayed reaction technique, was more interested in discovering the representative factors which enabled the monkeys to respond correctly in the various experimental situations than in establishing maximum periods of delay. The experimenter placed some food under one of two cups, placed somewhat differently with regard to the subject in the four set-ups employed. A board was placed in front of the cups so as to prevent fixation during the delay interval. The monkeys were found to respond accurately to an absent stimulus after a delay of from 15 to 20 hours without bodily orientation. In order to analyze the processes involved in the delayed reaction, qualitative tests were developed in which lettuce was substituted, unseen by the monkey, for the banana. There were typical differences in the behavior of a monkey when he found the lettuce he had seen placed under the cup, and when he found the lettuce under the cup where he had seen the banana placed. Tinklepaugh believes that the nature of the subject's behavior when either the food or the container is secretly substituted is a criterion of the basis upon which he responded. In the actual choice of the container, however, the monkeys responded only to their relative positions, and the behavior when the substitution method was used merely demonstrated the fact that both the container and the reward were functional parts of the stimulus.

Nellmann and Trendelenburg (15) used a wooden box with a

hinged cover for testing memory in the monkey. Great care was taken so that the side that was hinged could not be distinguished on the basis of external appearance. If the food was placed in the box and the box turned 180 or 360 degrees in the horizontal plane, the monkey could react correctly after a very short interval, but failed to remember the side of approach if half a minute was introduced after the turning of the box. These same investigators used another method which is also applicable to the testing of the delayed response, although they did not utilize it for this purpose. A cherry was placed under one of two flower pots in front of the cage. The monkey could turn up the correct pot if they were turned 180 degrees so as to reverse right and left, or if the pots were each turned 360 degrees and thus returned to their original position only placed a little closer to the cage. The monkey was not diverted by the change, and continued with further experimentation making correct immediate choices.

Some less formal tests have been devised for use with animals, approximating natural conditions and therefore more comprehensible to the subjects. After Buytendijk (4) had thrown four pieces of apple successively in different directions, his monkey went to each one in turn, picked it up and ate it. After eating the third piece he paused a short time, and then went for a piece which had fallen underneath a board.

In Cowan's experiment (5), the cat received food in an adjoining room when the experimenter appeared at one door of the room, and did not obtain food when she appeared at another door on the same side of the room. After the problem had been mastered, delays were introduced, and the cat could respond correctly in a majority of the trials after a delay of 30 seconds without constant orientation.

Adams (1) modified Cowan's method somewhat by placing food in one of four boxes which could be entered by means of a door that was easily pushed open by a cat. The cat was taken out of the room, and after a predetermined interval of delay returned to the experimental room. During the interval all of the boxes were handled and filled with food, and the experimenter left the

room before the cat was released, so that no cues could be received from extraneous sources. With one of the two cats used, accurate responses were made after delays of 16 hours or more. The younger of the two cats was easily distracted, and could not respond accurately above 15 minutes after the food had been placed in the box. The long delays obtained by Adams appeared to be due to the ease with which the problem was learned and comprehended. Adams points out the marked conflict between the memory of seeing the food placed in the box, and the memory of having eaten the food in another box in the previous trial. To correct for this he believes that the interval between the trials should be about three times as long as the length of the succeeding delay period.

The buried food experiment was devised by Köhler and has been used with several types of subjects. Köhler (11, 12, 13) reports that apes are capable of delayed reactions, which according to his explanation, strongly suggest the use of memory ideas. Pears or tomatoes were buried in the sand just outside the cage and were so covered up as to give no visual or olfactory cues. The apes, having watched the burying of the fruit in the sand outside the cage, on being released after $16\frac{1}{2}$ hours, ran immediately to the burying place and dug out the fruit.

Yerkes (23) gave four trials in the buried food problem to the gorilla as a rough measurement of her memory span. He states that memory for locations in which food has been concealed persists for at least two days in the gorilla. Slight errors were made, however, in the estimation of distances. Upon returning after a week, she exhibited definite memory of her previous experiences in these locations. Positive results were obtained on the chimpanzees used by Yerkes and Yerkes (25) in the buried food experiment after delays of two days, with some indications of memory after four days. Evidences of memory for persons and situations have been observed after ten month intervals in both the gorilla (23) and the chimpanzee (25).

Kohts (14) has ingeniously devised a very different type of test for measuring delayed reactions. The chimpanzee was shown an object and required to select from a number of objects placed on

the table before it, an object identical in one or more respects with the sample shown by the experimenter. This experimental situation of choice from a sample offers many risks of error, but Kohts was well aware of these and controlled and checked her observations accordingly. By using this method the stimuli could be varied in place of presentation, relative position, form, time of exposure, number and arrangement. When a colored plate was shown for two seconds, the chimpanzee could make a correct choice from a number of different ones if the delay did not exceed 15 seconds.

Experiments with children. The delayed response has been more adequately and extensively studied in animals than in

TABLE 2

The length of delay secured with various children

SUBJECTS	DELAY	ALTERNATIVES	EXPERIMENTER	TRIALS ON DELAY
8 year girl	28 minutes	3 lights	Hunter (7)	38
6 year girl	35 minutes	3 lights	Hunter (7)	15
6 year boy	35 minutes	3 lights	Hunter (7)	47
6 year boy	25 minutes	3 lights	Hunter (7)	41
2½ year girl	50 seconds	3 lights	Hunter (7)	507
1 year girl	10 seconds	3 boxes	Hunter (9)	264
2, 5 year boys	1 minute	2 bowls	Tinklepaugh (17)	
1½ year girl	8½ minutes	3 bowls	Rugh (16)	28

children. The difficulty of securing young children and of developing a satisfactory method of investigation has seriously retarded the study of their mnemonic processes. Since there are so few experiments reported in the literature, each case will be included in table 2 summarizing the results of the various studies. In this table are given the age and sex of the subjects, the length of the delay obtained, the alternatives employed, the experimenter and the number of trials given on delay.

For testing the delayed responses of children Hunter (7) used a modified form of his apparatus for the animals. One of three lights was turned on over the button that rang the buzzer, and the child's problem was to find this button at the first trial, when the light was on (in the learning trials), and then (in the delayed

reactions) after the light had been turned off for a certain interval of time. Four of the five children used in this experiment learned the association between the noisy button and the light in six trials. The delays were increased continuously until an error was made, then either decreased, or continued on this level until there was a reasonable certainty that the maximum delay had been obtained. The delays attained ranged from 50 seconds for a girl two and one-half years of age to 35 minutes for a six year old girl. An eight year old girl who could press the correct button after a delay of 28 minutes, could remember the button that she had pressed last the day before. This brings out very strikingly, the effect of making an overt response in increasing the child's retention of a particular situation. It also suggests the possibility that under slightly different circumstances, children of the ages tested would be able to remember for much longer periods of time than is indicated here.

The measurement of the delayed response in children is further complicated by the varying effects of candy and praise as motivation in the response for individual children, of the diversions offered during the interval of delay, and the conversations occurring among the children between the trials. Hunter (9) eliminated the difficulties involved in this experiment, when he formulated a direct method not necessitating any training or accustoming on the part of the subject.

Hunter (9) tested his own child at 13 months by using three boxes with hinged covers in which desired toys could be placed. The child was seated in front of the boxes, all of which were within easy reach, and her attention was directed to the placing of the toy. After a predetermined interval, during which time she was prevented from getting the toy, she was permitted to respond. She opened the correct box first in 72 per cent of the trials after delays varying from 8 to 12 seconds. Hunter noticed a tendency to open that box first in which the last toy had been found. Bodily orientation played a more significant part in this child's responses than in the responses of those children used in the three-light buzzer situation, where bodily orientation played no discernible rôle in the reactions. Hunter (9) interprets her

correct responses as a result of certain cues which were associated with certain differential responses and were selectively re-aroused when she was again confronted with the three boxes.

In order to compare children's behavior with that of monkeys when substitutions were made, Tinklepaugh (17) placed pieces of candy under one of two plates, and in the absence of the child substituted a different kind of candy. After one minute delays, both of the boys tested went immediately to the correct plate, and on finding a different type of candy than the one placed there, they evidenced similar surprise and behavior as that shown by the monkeys under similar circumstances. In a comparable situation, when Rugh (16) placed an object under one of three pans in front of a child one and one-half years old, she was able to react correctly after an $8\frac{1}{2}$ minute delay.

The duration of an impression after which one recollects a past experience has been demonstrated in Wislitzky's, "Experimente über Gedachtnis und Erwartung in der fruhen Kindheit," of which a preliminary report is given in Bühler's book (3). If an object is hidden, the child is then diverted for a period of time, and later permitted to seek it if he remembers the disappeared object spontaneously, the period of delay after which a correct response can be made increases from 5 minutes at one year to 20 minutes at two years, and 30 minutes at three years. There is no further increase in the length of the delay, but the number of objects that can be remembered increases from one at one year to six at six years.

Several authors have used geometric figures for testing immediate memory, and although they have not applied these to the measurement of delayed responses, they suggest their use for this purpose. In the tests developed by Fischler and Ullert (6) for the study of immediate memory, two of the tests are suited to preschool children, the presentation of pictures and the geometric designs. Thirty pictures, all familiar to the children were presented in succession, and after ten seconds they were required to tell something about each of the pictures seen. In another test nine geometric figures were exposed on a board for ten seconds. After 30 seconds, the child was asked to choose the nine blocks

from 25 that were placed before him. This test was first developed by Bernstein (2) for feebleminded children. The figures were chosen because they had no appropriate names, no associative value, and so that at least one figure could easily be confused with each of the ones seen. The performance in this test, as opposed to one in which forms having some previously existing association were used, is largely dependent upon the ability to perceive minute differences. The development of the concept of like and different in the perception of geometric forms is an important factor in the child's ability to make an accurate and discriminating response. A clearly defined perception is of even greater importance in a delayed response than in an immediate one.

The foregoing review of the literature on delayed reactions indicates very plainly the need of further studies of both animals and children. In formulating the various methods for studying the delayed responses of children, an effort has been made to utilize the advantageous elements in the previous investigations and to obviate as far as possible the undesirable features of the methods that have been used.

II. EXPERIMENTAL RESULTS

Purpose of the experiments. Four methods for measuring delayed reactions in young children were formulated in order to answer certain questions centering around the general problem. Up to the present time, no satisfactory maximum periods of delay after which correct responses can be made have been determined for a sufficient number of children to render the results statistically reliable. The majority of the previous experiments have been carried on with single children over comparatively short periods of time.

Finding the maximal period of delay for each child in the various experimental situations has been an important, but not the only purpose of this investigation; in fact in many cases this could not be obtained satisfactorily. The behavior of the children when the stimulus was given, during the delay period, and when they were confronted with the situation for the response were

recorded in detail for each trial. The vocal responses as well as the overt bodily behavior offer some cues as to the manner in which the child actually remembered how to respond correctly after the delay, and as to the individual differences in the length of the maximum delay obtained. The children's responses after several trials also gave interesting data as to the relative mnemonic values of the stimulus given and the previous responses made by the child.

Besides their value for studying the simple delayed reaction, the tests have been chosen because they offer further possibilities for experimentation. When maximum periods of delay have been established for individual children, a basis will be provided for determining the consequences of modifications in the procedure upon the length of the delay attained and their behavior. Formerly, no adequate technique had been devised that gave maximum periods of delay sufficiently short to permit the measurement of the effects of varying the stimuli. Unless the maximum delay is comparatively short, due to the rapid mental growth of children at this age, and to the necessity of long intervals between the trials to avoid the perseverative effects of previous responses, the child becomes a different individual before enough trials can be obtained to secure any definite results. In an attempt to devise a method which would satisfy the above requirement, several tests were adopted and tried out, the procedures and results of which will be described in this chapter. The situations satisfy the criteria for the measure of a delayed response as formulated by the previous investigators, in that they are adapted to the subject, require no trials for learning the manner of response demanded, provide a means for presenting one of several stimuli which are equally effective, and present no differential cues to the subject during the period of delay. The experiment necessitated behavior similar to that in numerous other experiences of the nursery schools in which the subjects were enrolled.

General procedure. In each of the experiments, the period of delay after the first trial was determined for each child by his success after various intervals that were interposed after the

presentation of the stimulus. For the first trial, a period of approximately equal duration was introduced for all of the children. The intervals that were planned, however, could not always be carried out, due to absences and to changes in the nursery school program. The measurement of the maximum length of the delay is necessarily largely a trial and error process, since it is impossible to determine exactly the time when the child distinctly remembers the correct response, and when he forgets it. In fact, it is highly probable that there is a "zone of forgetting" where the remembered stimulus is gradually losing its potentiality for evoking a response. The trials were not as widely separated as could be desired, but since the experiments were in a formative stage, it was believed that the increased number of trials on individual children would more than compensate for the lessened reliability caused by the perseverative tendency in successive responses.

Observations. A cumulative record card was kept for each of the children for each experiment in which he participated, on which was recorded the stimulus given, the date, hour, behavior, and verbatim responses, for both the presentation of the stimulus and the response for each trial. All of the children in these experiments were given numbers according to their date of birth, and will be referred to by these in the subsequent discussion. The maximum delay, in case one was determined, the child's chronological and mental age at the time when the stimulus for this maximal delay trial was given, were tabulated for each experiment participated in by the child.

The maximum delay, so called, is not the greatest possible delay for that child in a particular experiment, but that delay which has been determined on the basis of many trials, and which is the greatest possible delay that could be obtained under the described conditions. In determining this maximum delay, each child's records were carefully analyzed in order to select the longest delay obtained with an unquestionably correct response. The child's conversation, his speed and behavior in reacting, as well as his responses on other trials were utilized in the determination. This value is affected to a certain extent by the length of

the delays used, as well as the judgment of the correct response, or one which appears to be questionable or due to chance. Whenever there were sufficient data, however, to permit an estimation of this maximum delay, it was recorded, since this furnished valuable results as to the nature of the child's reactions in the various experiments, and material for comparative purposes.

In order to provide additional material for this study, moving pictures were taken of several children reacting in the four experiments. From these, a number of prints were made which will be discussed in connection with case studies of the children in the various experiments.

Subjects. Sixty preschool children acted as subjects in this investigation. Since the length of the delays given was determined largely by the experimenter's evaluation of the child's performance, it was decided that an intensive study permitting of many trials for individual children would be more valuable than securing a few scattered trials on a larger number of children.

Forty-nine children were in the Child Institute at the Johns Hopkins University. Nine of these children were tested at various intervals for two years, the others either during 1928–1929, or 1929–1930. This group included children whose chronological age range at the time when the first delayed response trial was given was from two to five and one-half years.

Eleven of the children were obtained from the Arbutus Methodist Nursery School. These children varied in age from three and one-half to five and one-half years. They had never been subjects for any experiments or formal tests up to the time when they were used in this investigation.

The mental ages, as derived from the Stanford-Revision of the Binet-Simon tests were available on 35 of the children from the Child Institute. Eight of the younger children and those who were only temporarily enrolled in the Nursery School had not been given this test. Ten of the 11 children in the Arbutus Nursery School were tested by the experimenter. Every possible effort was made to obtain mental ages on all of the children, so that the omissions may be considered unavoidable.

A brief summary is presented in table 3 of the children included

and the number of trials given on delay in the four experiments. The number of trials that were not completed, due to absence of the subjects, is given in the column at the extreme right.

Due to the impossibility of obtaining a large number of preschool children, many of those employed in this study were given more than one of the tests. The extent of the overlapping in the tests may be gathered from the following data: 17 children were given all four experiments, 5 were given three, 17 were given two, and 21 children were given only one of the experiments. In several cases, two of the experiments were carried out on the same child during the same period of time, thus introducing some interferences, but the results indicated that this concurrent double

TABLE 3

A summary of the experiments given

TYPE OF EXPERIMENT—DELAYED RESPONSES TO:	NUMBER OF ALTERNATIVES	NUMBER OF CHILDREN	NUMBER OF TRIALS INCLUDED	NUMBER OF INCOMPLETE TRIALS
I. Position of a concealed object	3	46	280	5
II. Exposure of familiar forms	6	27	120	3
III. Exposure of geometric forms	6	37	242	8
IV. Exposure of unfamiliar forms	6	28	121	2
Totals			763	18

series did not detract from the value of the data obtained. As far as possible, the trials on the children used in more than one experiment were distributed so as to minimize the conflicting effects. The actual time spent in the experimental room was approximately one minute for giving the stimulus and for the response, although in some cases the latter was a trifle longer when there was a marked hesitancy on the part of the subject in making a choice.

Throughout this study, the investigator encountered no difficulties in securing the children's cooperation. Two of the younger children were a little hesitant the first time that they were asked to "come and play the game," but this reluctance was soon replaced by a willingness and even eagerness to come with the experimenter. Comments such as "Take me," "Can I

come next time?" or "When will it be my turn?" were frequently made. Several of the children came to the experimental room without being asked, hoping that they would be given a trial. This behavior was manifested, equally, with regard to each of the four experiments.

I. Delayed responses to the position of a concealed object

Experimental procedure. In the first experiment an animal cookie was hidden, in the presence of the child, under one of three plates, and after a definite predetermined interval the child was again confronted with the situation and asked to find the object. The apparatus consisted of three china soup plates placed on a table 28 by 45 inches at a distance of 6 feet from the subject, who was seated on a small chair when he was not reacting. Animal cookies were chosen as the stimuli, to be used also as rewards, because they were not harmful as food, the children liked them, and because they could be readily eaten and thus disposed of without offering any accessory stimulation to the children beyond the experimental room.

The child was asked to come with the experimenter into the experimental room where he was told to sit on the chair facing the table on which the soup plates were placed. The experimenter took the animal cookie in her right hand, and showing it to the child said, "Do you see this little animal cookie? (Paused for the child's assent.) Now I am going to hide the animal cookie under *this* plate. (Lifted a plate with the left hand, and placed the cookie under it with the right hand, standing always to the right of the plates so that they were within full view of the child, stepped back from the table and continued.) If you can find the animal cookie when you come back here, you may have it to eat. Now you may go and play."

The animal cookies were placed under the plates in a definite sequence but in an irregular order. Each plate was used an equal number of times in order to prevent habitual responses to one position, but the same plate was never used in two consecutive trials.

After a predetermined period of time, the child was again

brought into the room. As soon as the child was seated, the experimenter took a position a little to the right of the subject's chair and asked the child, "Can you find the animal cookie?" No other directions were given, but these were occasionally repeated in case the child did not hear or comprehend the directions the first time. When the child got up to respond, the experimenter immediately passed out of the child's field of vision and could only be seen by him if he turned his head around while going to the plates. Unless the child had received some cue from the experimenter while the directions were being given, there was no possibility of him receiving any without that the turning of the child's head gave evidence of his indecision in the choice of the correct plate. If the correct response was made, the child obtained the animal cookie, and after having eaten it, went out to play. If the child turned up the wrong plate, this was said to the child, "You didn't find the animal cookie today did you? (Pause.) I guess that you will have to come back some other time to see if you can find it." There appeared to be no disinclination to react in this experiment in spite of continued failure to obtain the reward in successive trials.

The procedure in this situation needs some justification, since it departs slightly from that reported by Hunter (7 and 8), Tinklepaugh (17), and Rugh (16). A certain stimulus may have varying effects upon the length of the delay possible, due to the nature of the accompanying circumstances. In one case, the so called "release" for the response may be one which is associated with the response by practice, such as releasing the bar in Hunter's experiment (7) with the children. In a second case, the procedure in the response to the stimulus may be such as to definitely suggest the type of behavior required. There is less difference between the two methods described than would appear at first. When the child is trained to respond to a given release, this release has, obviously, just as much associative value in a given situation as the directions, "Can you find the animal cookie?" In either case, the child is still required to discriminate between the three plates presented, and to decide which one to lift up in order to obtain the reward. The only real difference

between the bodily release and the verbal command is the advantageous elimination of a learning series in the latter method.

In spite of the fact that an attempt was made to make this experiment as natural as possible, the objection might justly be brought against it, that the child rarely has to look for food under inverted plates, or to discriminate between three objects identical except for differences in position. Nevertheless, the situation was easily comprehended by the children and proved valuable in studying certain aspects of the delayed response. Its practicability for determining a child's maximum period of delay in a relatively simple situation was also demonstrated.

Experimental results. Children's behavior and verbal responses. A child's reaction to a new situation is very suggestive of his general behavior. His comments, ability to adapt to the new demands made upon him, and his interest in the first trial correspond very closely to that observed in later trials. Significant behavior observed, bearing upon the conditions of the experiment as a whole will be discussed here, while that pertaining primarily to interesting individual children will be given in a study of special cases.

The children were eager to find out about the new "game" they were asked to play. The reactions to the hiding of the animal cookie were varied in many respects. Several children pointed to the plate where the object was hidden, others reached for the cookie, and a few attempted to go to the plate immediately. In each case, as soon as the procedure for the stimulus presentation was completed, the child was sent back to his play group. One child commented, "That's a pretty trick, isn't it?" Very soon after the object had been hidden, several children asked if they could not come with the experimenter again. One child came from second to first floor without receiving permission, and peeked in the door to the experimental room, with a very questioning expression on his face. When he was told that he could come back tomorrow, he immediately returned to his group.

The responses in the first delayed reaction trial ranged from complete compliance with the directions and immediate success, to absolute failure due to non-comprehension of the directions

or refusal to respond. Many children manifested uncertainty in choosing the plate where they looked for the reward. In such cases they would ask, "Where is it?", or "Is it in this plate?". Where this indecision was noted, the response was considered a failure or a questionable success. A number of the younger children hesitated in lifting the plate, usually shoving it around, looking helplessly at the experimenter at frequent intervals. These children were urged to lift the plate they were responding to, so as to obviate the occurrence of this type of response in later trials. The one child who did not understand the directions at all in the first trial, had learned English very recently, and it was necessary to give him several trials in order to teach him what was required in the response.

Many children as they became increasingly familiar with the experiment, began to leave the room as soon as the cookie was hidden, before the directions were completed. When responding, they began to walk towards the plates as soon as they heard, "Can you find," instead of waiting for "the animal cookie," which indicates that the question merely acts as a "release" at the time for the response. In most cases the child was not permitted to lift up more than one plate, whether the response was correct or not. When this was allowed, it was in order to study the child's behavior, and in two instances to avoid a potential emotional upset which would, perhaps, have conditioned the child negatively to the experimenter. A majority of the children took this prohibition as a matter of course, and did not attempt to lift up any other plate if they did not obtain any reward under the first one.

As well as indicating uncertainty concerning the plate to be responded to, most of the children at one time or another throughout the experiment, expressed a curiosity concerning the whereabouts of other animal cookies. The most frequent expressions were, "Are there any under there?", indicating the other two plates not responded to, or "Where do you get the cookies?", "Is everybody going to get one?", or "I have animal cookies at home." A few of the children asked if another child, giving his name, had received a cookie, or if they were afraid that some other child would take it before they returned to the room they would

say, "Don't let—get it, will you?", or "I bet somebody takes it," or "Now don't you give it to anyone else."

When a child did not find the reward, he usually assumed one of two attitudes, either he admitted forgetting, or he excused himself on the basis that the experimenter or some child had taken the reward in his absence. After an absence of 40 days, child 10, when asked to find the animal cookie replied, "Staying at home and sleeping made me forget." Another child volunteered, "I always forget to go in here and get it." Other children simply said "I forgot." Two of the children asserted that the experimenter had fooled them, the one angrily, and the other behaving very complaisantly as if it were a part of the game. One child, when he did not find the reward asked, "Who ate them all up." The spontaneous remarks made by the child when the cookie was hidden and when he did or did not find it, were the only cues that could be obtained as to the nature of the mnemonic processes involved. When the final trial had been completed on each child, if he had found the reward, he was asked, "How did you find it?" No amount of questioning would elicit any answers other than, "I just remembered," "I don't know," "I saw you put it there last time I was here," or "I knew it was there."

All of the children were pleased with the game and the reward. Some of the children wished to take the animal cookie to show the other children, but they were requested to eat it in the experimental room so as not to disturb the other children. One child did not eat the cookie saying, "I am going to save the cookie, because my mother won't let me eat between meals." The reward part of the situation was the only one mentioned by any of the children in their play group. The nursery school teachers reported that in no instance throughout any of the experiments, did the children mention any of the conditions in either this situation or in any of the others except the fact that they had found or had not found the animal cookie. This was most gratifying, since all conversation and reenforcing of the stimuli given through repetition would seriously interfere with the validity of the delays obtained. The group apparently had no effect upon the reactions in the experiment except to accentuate the desire to participate as frequently as possible.

When the children became more accustomed to the situation, their attention was not centered solely upon the process of seeing the cookie hidden and finding it after a period of delay. Several children requested, "Let me hide it," or "Put it under the middle plate this time." One child asked, "Why do you put it under there?" Comments were frequently made concerning extraneous matters such as the child's new clothes, his activities, objects about the room, and his play at home.

Quantitative results. Interesting and valuable as this description of the children's behavior and verbal responses in this experiment is, a quantitative analysis of the results obtained is also necessary. The data do not lend themselves very well to statistical treatment, both because of the limited number of

TABLE 4

The frequencies of the stimuli and the responses in percentages for the various positions of the plates

POSITION OF STIMULUS	TOTAL NUMBER OF TRIALS	RESPONSES IN PER CENT OF TOTAL NUMBER			
		1	2	3	None
1	93	61.5	26.8	8.5	3.2
2	89	17.9	59.5	22.6	
3	98	18.4	23.5	56.1	2.0
Totals.....	280	32.5	36.1	29.5	1.8

cases, and because the determination of the delays is not entirely objective. The statistical analysis of the data is not final in any sense, but merely suggestive and indicative of results that would probably be obtained by further study of additional children.

The plates under which the object was hidden were numbered according to position from left to right, one, two, three, and will be referred to in this manner. The frequencies of the stimuli and the responses in percentages for the various positions of the plates are given in table 4.

The total number of times that a cookie was placed under plate one, was 93 times. Of the responses in these trials, 61.5 per cent were correct; of the incorrect ones, 26.8 per cent were to plate two, 8.5 per cent to plate three, and 3.2 per cent were not re-

sponded to at all. Each plate was used approximately the same number of times as a stimulus, but in spite of this fact, there was a marked preference for the middle plate. A larger proportion of the incorrect responses were made to plate two, then to either plate one or three. This may be due primarily to the fact that since the table was straight, the side plates were a little further away from the subject when he was seated for the response, than was the middle plate. Further, when the child was uncertain as to the plate where the animal cookie was, he would walk to the table, fluctuate in choosing between all three plates, remain standing near the middle one, and finally lift this one up in order to obtain the reward if it was there. No cues were derived from the children affording any explanation of the few incorrect responses

TABLE 5

An analysis of the incorrect responses made in Experiment I

INFLUENCING FACTORS IN THE 115 INCORRECT RESPONSES	PER CENT
Response made in preceding trial	44.4
Habit response (made in several preceding trials)	17.4
Hidden in previous trial	13.9
Incorrect response in first trial to middle plate	6.9
No basis for choice	13.9
No response	3.5

made to plate three, when the cookie had been hidden under plate one. One would expect more confusion between the end plates than actually occurred. Several of the older children did not remember where the cookie was, and did not guess at the place where this might be obtained, hence no response was recorded for this trial.

The nature of the errors made in this experiment manifest, very strikingly the marked perseverative effect of the previous correct response. Of the total number of incorrect responses made (115), the proportions given in table 5 constitute some interesting results.

Combining responses due to habit, and to only one previous correct response to that plate, it will be seen that 61.8 per cent

of all the incorrect responses may be considered as perseverative. It is only reasonable to expect that when a child has seen an object which he desires placed under a plate, and that subsequently it has been obtained there, that he should go to this plate again when making the next response, in spite of a different intervening stimulus, providing the interval between trials is not sufficiently long. In cases where the child made a correct response after, for instance, two days, and made an incorrect perseverative response after two days in the succeeding trial, the former delay was considered as a definite indication of memory for the stimulus, whereas, if the latter failure had not been perseverative, the correct response after a two day interval in the first case was considered as questionable, providing the child's behavior in the two cases did not permit of accurate evaluation.

It would have been profitable to study the length of delay possible for obtaining a perseverative response, providing this had been planned in setting up the experiment. The situation would enable a comparison of the length of time which a child could remember when he had been stimulated once or twice, since responding in a given trial is equivalent to strengthening the previous stimulus. With the data obtained in this experiment, the above analysis would be of little value, since the intervals between the trials were much less objectively determined than the lengths of the various delays used. Furthermore, when there are only three alternatives, if the response is incorrect, the chances are half and half that the response will be perseverative, because no plate was ever used twice in succession as a stimulus for one child. Individual children differed markedly in the frequency of incorrect perseverative responses. It appears that for them, the receiving of the reward had greater menmonic value in comparison with seeing the cookie placed under the plate, than it had for other children. Individuals who continue to respond incorrectly to the same plate three times in succession differ greatly from those who never make an incorrect perseverative response despite a comparable trial series. A greater number of incorrect perseverative responses were noted after the first trial than after any of the succeeding ones. This was undoubt-

edly due to the greater attention and interest manifested in the new situation which enabled the child to remember the stimulus longer than when, in the later trials, he had had several different stimuli presented to him.

In order to determine any relationship existing between the length of the interval between the trials, that is from the response in one trial to the stimulus for the next trial, to the length of the delay obtained in the succeeding trial, these data were tabulated according to three characteristics: the length of the delay in each succeeding trial, the success or failure of the response, and the ratio of the interval between trials to the length of the delay in

TABLE 6

The proportion of correct and incorrect responses for various ratios of the interval between trials to the length of the succeeding delay in Experiment I

INTERVAL ÷ LENGTH OF SUCCEEDING DELAY	NUMBER OF RESPONSES INCLUDED	PER CENT CORRECT	PER CENT INCORRECT	PER CENT OF WHOLE GROUP
0.0–0.4	55	45.4	54.6	23.5
0.5–0.9	28	60.7	39.3	11.9
1.0–2.9	58	43.1	56.9	24.9
3.0–9.9	36	66.7	33.3	15.3
10.0–19.9	22	72.7	27.3	9.4
20 and over	35	71.4	28.6	15.0
Totals.....	234	53.8	46.2	100.0
First trial....	46			

each succeeding trial. This ratio was obtained by dividing the length of the interval between every two trials by the length of the succeeding delay. The importance of determining the interval between trials for securing reliable maximum delays may be gathered from table 6 giving the proportion of correct and incorrect responses for various ratios of the intervals between trials to the length of the succeeding delays.

Since there are 46 children included in this first experiment, there are 234 trials on delay included in this table, because the first trial was, of course, not preceded by an interval to form a ratio. For the shorter delays, the ratio was greater than for the

longer ones, since obtaining several trials with long delays necessitated the utilization of the time in the delay period rather than in the interval between trials.

It may be noted from table 6, that although the increase is not uniform, the proportion of correct responses increases from 45.4 per cent when the ratio is less than 0.5 to 71.4 per cent when this ratio is over 20, that is, when the interval between the trials is at least 20 times as great as the length of the delay in the succeeding trial. The fact that these ratios are more prevalent with the shorter delays, which also have a greater proportion of correct responses, makes it difficult to allocate the causative factor. Undoubtedly both play an important part in the results obtained, but the predominance of incorrect perseverative responses in the errors made suggests that well spaced trials will give the most valid results, at least in so far as obtaining satisfactory maximum delays are concerned. Approximately three-fifths of the trials were given after intervals of less than three times the length of the delay on the following trial. Until satisfactory techniques have been evolved, there are so many other sources of error in measuring the delayed reaction, that one is justified somewhat in neglecting to adhere strictly to any definite ratio. But it is certain, that unless the trials are spaced at least partially in accordance with the length of the delays used, the results will be so conflicting as to prove of slight value, even in formulating a method of study.

The data were also combined with reference to the success of the responses in relation to the length of the delays used.

The proportion of correct and incorrect responses as given in table 7 indicates a decreasing percentage of incorrect responses after longer periods of delay. This means that a majority of the children could respond successfully to an absent stimulus after a short intervening period of time, but that as these intervals increased, more of the children failed to respond correctly, notwithstanding the fact that the delays were based primarily upon each child's performance in preceding trials. All of the trials given are included in this table, so that the totals differ slightly from

hose in table 6 where the 46 first trials are not included. The percentage of correct responses decreases from 64.8 after delays of from one to three days, to 28.6 after delays of over 30 days.

Maximum delays were obtained on 42 children in this experiment, but these results will be included in a comparison of the delays obtained in the four experiments, together with the relationships existing between these delays and certain other factors.

Case studies. In a statistical analysis of data such as has been given in the preceding pages, interesting features of the individual records are hidden. Some cases have been selected which demonstrate the type of behavior manifested, both when the stimulus

TABLE 7

The proportion of correct and incorrect responses after various periods of delay in Experiment I

LENGTH OF DELAY	NUMBER OF RESPONSES	PER CENT CORRECT	PER CENT INCORRECT
days			
1–3	142	64.8	35.2
4–9	71	55.0	45.0
10–14	25	52.0	48.0
15–20	9	44.4	55.6
21–29	26	46.2	53.8
30 and over	7	28.6	71.4
Totals.....	280	57.9	42.1

is presented and when the delayed response is made, and which throw some light on the effects of various uncontrolled factors in the experiment upon the length of the maximum delay obtained. The length of time necessary for both the stimulus presentation and the response was longer than in any of the other experiments, and hence the records provided a greater wealth of material for individual analysis. Cases have been chosen which illustrate the ability to make correct responses after long periods of delay, the perseverative effect of a correct response, the effect of excitability, high emotional tension, and variations in the stimulus upon the length of the delay obtained.

Child 37

This child responded correctly after the longest delays of any of the children tested; in none of the trials was an incorrect response or even a questionable correct one made. She was given two trials in 1929; having made a correct response on the first trial after one hour, she made an immediate correct response on the second trial after an absence of 64 days. She went directly to the plate where the cookie had been hidden the time before, and when asked, "Are there any cookies under the other plates?" she answered, "No." Since this delay was three times as great as that obtained for any other child, it was not counted as a maximum delay. In 1930, she responded correctly after a delay of 34 days, which was also longer than any delay obtained for any of the other children. Her chronological age at this time was 50 months, and her mental age 65 months. At the time the cookie was hidden for the last trial, she gave some evidence of the method she used in remembering, and gave adequate justification for assuming the delayed response after 34 days to be a result of correct memory. She pointed to each of the plates, saying as she did so, "I look at them and say, one, two, and than I look under three (stimulus in this case) and get the animal cookie." By reenforcing the stimulus in this way, she was enabled to make a correct response after a much longer period of time than she would have if she had not used these memory devices. Her responses in the other experiments were about the average for her age.

At the age of 38 months, this child came up to the experimenter and said, "See my new watch." About 20 minutes later she said, "See my new watch. Oh, I showed you before didn't I?" About 15 minutes later she said, "I showed you my watch before didn't I?" This incident is illustrative of her general behavior.

Child 17

No child expressed such great satisfaction with his ability to respond accurately to this situation as did child 17. When the cookie was hidden the first time he said, "I saw where. I know right where you put him, because you put him right under that plate" indicating the plate. After responding correctly in the first trial he said spontaneously, "I can find it because I saw you. There aren't any under there, are there? Why didn't you put it under there?" He surveyed the reward disparagingly, "This is too little for me to take home." His maximum delay was 17 days when he was 53 months old with a mental age of 70 months. His superior attitude in this experiment was consistent with

his behavior in the nursery school, where he always maintained that all the toys belonging to the school were mere nothing as compared with the marvelous things provided in his home for play.

Child 55

The marked perseverative effect of receiving an animal cookie under one plate upon subsequent responses is remarkably demonstrated in this child's record. He obtained the reward in the first trial under plate one, and continued in the next four trials to make incorrect responses to plate one, without the slightest hesitation. He then made a correct response to plate two after a delay of one day, and continued responding to this plate for the remaining six trials given him. With a child of this sort, it is absolutely necessary to keep the intervals be-

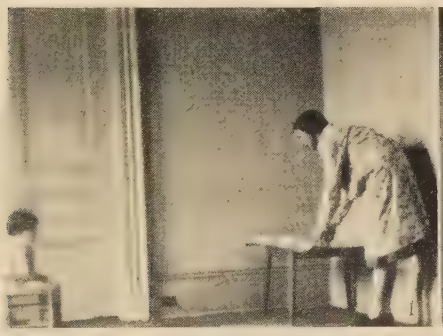

FIG. 1. PRESENTATION OF STIMULUS EXPERIMENT I

FIG. 2. RESPONSE IN EXPERIMENT I

tween the trials at least three times that of the length of the succeeding delay. For this child, the interval could profitably be increased to ten times. His maximum delay was one day when he was 32 months old.

This child is shown watching the hiding of the animal cookie, and lifting up the correct plate in figures 1 and 2 respectively.

Child 51

This child exhibited the greatest variety of interests in his conversation before, during, and after the trials in this experiment. His maximum delay was six days when he was 43 months old, and had a mental age of 56 months. When coming downstairs for the first trial he volunteered, "I smell chicken. I smell fish." When I showed him the

animal cookie he said, "Can I smell it?" After I had hidden the object, it was difficult to persuade him to leave the room. He insisted, "I want to see the animal cookie." When the experimenter suggested that he go finish his steamship, he returned to his play group immediately. Coming downstairs for the response on the first trial, he said, "Can I have the animal cookie?" After obtaining the reward he asked, "Are there any under there?" pointing to plate two, and later, "Haven't you got any more?" At each stimulus presentation he would invariably say, "I see," and when asked to find the animal cookie, "I could." He manifested great reluctance in leaving the experimental room, either coming back and peeking through the partly open door, or making elaborate plans for his return at a later time for finding the reward. His favorite expression when he saw the experimenter at any time was, "I have come back," suggesting that he would like to be of service.

After an absence of three months, on seeing the experimenter in the hall upon his return, he said, "Miss S.—, can I get the animal cookie?" The stimulus was given, and he wanted to look for the reward immediately, "Why can't I get it now?" He made a successful response after six days in this case. At all times he showed a great desire to obtain an animal cookie. It is impossible to say whether his interest in the "game" or his scattered attention had the greater influence upon his memory for the position of the plate containing the concealed object.

Child 27

Child 27 was a foreign-born child who had learned English very recently and did not understand it very well. When the stimulus was presented, his expression was always, "What is that?". He did not understand the purpose of the experiment, and failed to find the cookie after a two day delay on the first trial. He was then given a trial with a one minute delay, and his response at this time indicated the nature of his difficulty. He went over to the table and *looked* at the writing on the bottom of the plates, as if to find the object pictured there. He was urged to lift the plate, in order to teach him the method of response and he found the cookie. Upon returning to the playground, he jumped up and down hilariously, saying repeatedly, "I had a good time." On the third trial he wanted the cookie when he saw it, and asked "Why can't I have it now?" In all succeeding trials, however, he left the room as soon as the directions had been completed, having learned that an interval must elapse before he would be permitted to look for the cookie. In the response in this third trial he said, "It is under this plate," walk-

ing to the plate and obtaining the cookie there. According to his teacher he had been irritated all morning because he had not been permitted to react in the experiment, and the experimenter was greeted with, "You said I could come next time," in an accusing tone of voice. In the next trial when he did not find the reward, he could scarcely be made to leave the room, because he wanted to look under the other plates. When he asked, "When can I find it?" and was answered, "Some other time," he said, "I want to be by myself," perhaps because he thought that he could find the reward better then. He made an incorrect response in the following trial but was permitted to look under the other plates to find the cookie in order to avoid any emotional difficulties such as were threatened in the previous failure. A somewhat longer delay was then tried, and in the response situation he walked immediately to the correct plate, hesitated and said, "You find it. Sometimes I don't find it." He walked around the room, returned to the plates, started lifting up one, put it down, went to two, returned to one and found the cookie there. His maximum delay was three days, when he was 56 months old, and had a mental age of 56 months. His excitement both during the stimulation and when he was responding, undoubtedly prevented him from remembering the position of the concealed object for a long period of time.

Child 4

This child was perhaps the least stable emotionally of any of the children tested. The atmosphere in the home was unfortunately not very frank, and the child, herself, was quite adept at fabrication. She could not find the animal cookie if delays were introduced of longer duration than 30 hours. Her responses when she failed to find the reward were either, "I am never coming down again," "You told me a lie," or "You fooled me." At another time when she did not find the cookie she said, "You told me last time you would tell me where it is. You are telling me stories." There never seemed the remotest possibility to her, that she could have forgotten where it was, or that it was through any fault of hers that she failed to find the cookie. After an interval of one day, when coming downstairs she said, "Did you put it an easy place for me? I am going to get it today. Now you watch me." She found the reward and wanted to take it upstairs. In spite of the predominance of incorrect responses she was always certain that she would obtain the reward before her response had occurred. She attempted to attract attention in various ways, either by falling off her

chair, or making queer faces. Her continual excitability prevented her from concentrating on any one thing long enough to remember it for any but a very brief period of time. Her chronological age when the maximum delay of 30 hours was obtained was 61 months, and her mental age was 63 months.

Child 40

An interesting example of the effect of the variation of the stimulus upon the length of the delay possible is demonstrated by this boy. He apparently was much interested in the experiment, but in the first six trials he was not able to remember the position of the cookie longer than half an hour. His mother, at this time, told the experimenter that the child was very fond of elephants, and so elephant animal cookies were used. When the object was hidden the directions given were, "Do you see this elephant cookie? etc." He had no difficulty in remembering where the *elephant* had been hidden after a delay of one day. His chronological age at this time was 39 months, and his mental age was 47 months. The use of the elephants instead of any kind of animal cookie increased his desire for the reward and enabled him to remember its hiding place longer.

Summary. Forty-six children were given a total of 280 delayed response trials in this experiment, where memory for the position of a concealed object was tested. The maximum delays obtained ranged from 1 to 34 days. Approximately three-fifths of all of the stimuli given were responded to accurately after the delays given. A majority of the incorrect responses were made to position two, that is the middle plate. The most influential factor in making an incorrect response was having obtained the reward in a certain position in the previous trial. The responses after shorter delays were correct in a larger proportion of cases than after longer periods of delay. More of the delayed responses were correct if the interval between the response on one trial and the stimulus in the succeeding trial was at least three times as great as the delay in the succeeding trial. The records chosen for individual analysis indicate interesting features of the delayed responses which could not be treated statistically, but which do give valuable data as to the manner in which a correct delayed response is made, and as to variations in the maximum delays obtained by different children.

The length of the periods after which the position of a hidden object could be responded to correctly was so great, that it would have been impossible to study the effects of modifications in the procedure upon the length of the delay obtained, by the use of this test. In order to get a situation which would yield maximum delays of short duration, and to study the children's reactions to a somewhat different set-up, experiment two was devised, using familiar forms as stimuli.

II. Delayed responses to the exposures of familiar forms

Experimental procedure. The delays obtained in the first experiment were too long to permit of any measurable variations. For this reason, several supposedly more difficult tests were developed. In this situation the control of conditions was planned for a more difficult response, offering multiple choices. Previous to the actual delay trials it was necessary to test each child's familiarity with wooden blocks of various forms, and his ability to name them. Two of each of these forms were made and outlined in black: a dog, horse, cat, camel, automobile, elephant, boy, duck, goose, kiddie car, rabbit, pig, and chicken. The method was similar to the one used by Kohts (14) with the apes, although her primary interest was in the ape's ability to discriminate form and color.

In the preliminary experiment, the forms were placed on a table within easy reach of the child who sat facing the table. The apparatus and method of presentation is illustrated in figure 3. Each form was presented in turn with these directions, "Do you see this block? (Holding one up immediately in front of him.) Will you point to one on the table exactly like this one?" Provided the child responds correctly the experimenter asked, "What is it?". Whenever the child could name the block, but not point to the one like it or vice versa, the fact was recorded. The six blocks that were chosen, were accurately pointed to and named by all of the children who could respond satisfactorily to the absent stimulus in the delay trials. The four youngest children in the group tested, could not name more than one or two of the forms, and did not understand the matching process. They were

given several trials on delay, but their responses gave no evidence of memory for the previously presented stimulus. The records of their performances are included in the discussion because of the interest attached to their behavior in a situation too difficult for them. The previously planned training of those children who were not familiar with the forms, in order to insure comparable effects of the stimuli, was therefore unnecessary. The blocks chosen were a kiddie car, cat, boy, rabbit, pig, and automobile.

FIG. 3. TESTING FOR FAMILIARITY OF FORMS

Although all of the children could readily point out and name each of these forms correctly, there was no assurance that they had equal mnemonic value, in fact one is led to believe from the experimental results obtained in this test, that they differ greatly in this respect, due primarily to the variety of their associations for the different children.

A form was shown in an exposure box constructed for this purpose. The box was 25 by 25 inches, and the form, which was placed on two pegs in the center of the black background, was

disclosed when the curtain to the box was pulled back by means of a cord at the right. Light was thrown on the block from above, and diffused by the use of milk glass. The apparatus for the stimulus and the response are pictured in figures 4 and 5 respectively.

When the child was brought into the room and seated, he was told, "I am going to show you something in here (pointing to the curtained box), and I want you to look at it very closely, so that

FIG. 4. APPARATUS FOR STIMULUS PRESENTATION IN EXPERIMENT II

the next time you come into this room you can show me one just like it." The curtain was then pulled, and closed after 5 seconds by releasing the string and thus permitting the weighted curtain to fall back into place. The child was then told to return to his play group. All questions pertaining to the stimulus given were answered as noncomittally as possible. When the stimulus was presented, there were no blocks on the table. Although the child was not asked to give the name or make any overt response, many of the children pointed to the form and named it. The

child's attention, vocalization, and overt responses during the stimulation are functional parts of his delayed response, so that in case the child was asked to name or point to the block, those children who would do so of their own accord, would be deprived of an advantageous and spontaneously initiated memory aid.

For the response, the six blocks were placed on the table in front of the exposure box, which was now closed. The blocks were arranged differently each time, so that the child could not

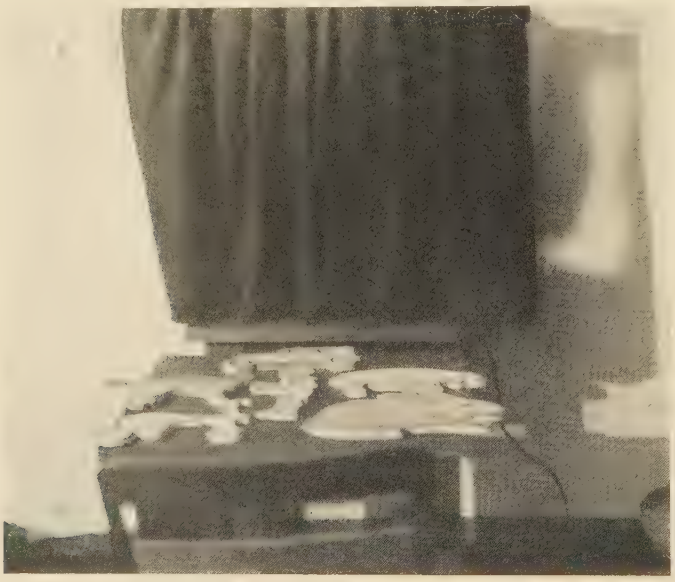

FIG. 5. APPARATUS FOR RESPONSE IN EXPERIMENT II

use the placements of the blocks as a means of remembering the one seen in the box. When the child was brought into the room, after an interposed period of time had passed since the presentation of the form, and seated he was asked, "Will you point to the block that you saw the last time in this (pointing to it) box?". The child's problem was to discriminate between the blocks and to choose the sample seen the last time. This form of questioning was used in order to eliminate the neccessity of training in the mode of response. When the child had pointed, the experi-

menter said, "That is fine," and the child left the room. In this situation, the child had no means of knowing whether or not his response was correct, and the behavior was, accordingly, different from that observed in the first experiment, where failure to find the animal cookie was sufficient evidence of the inaccuracy of his choice.

The children's reactions to the experiment. The reactions of the children to the experiment with familiar forms were considerably different than to the first experiment. The problem was somewhat more difficult for them to understand, and the response differently motivated than when it was necessary to remember the position of a concealed object. In spite of this, each child made an effort to remember the block seen in the exposure box, and appeared to be just as much interested in pointing out this block in the response situation as in finding the reward in the former.

The delays obtained in this experiment were the least satisfactory of the four experiments. During the months when these familiar forms were used as stimuli, there were many absences, and it was impossible to carry out many of the predetermined delays. In such cases, the child was permitted to respond when he returned to school, rather than permitting the trial to be incomplete and giving a new stimulus. In view of the results obtained, the latter procedure would certainly have given more successful responses than the method used.

Since the experimental room in this situation was on the same floor as the children, and the time which the children remained there was very short, there was little opportunity for observing significant differences in the children's behavior. Aside from a few comments made about the operation of the exposure box, the vocal responses of all of the children were almost stereotyped.

When the object was shown in the box, each child, with a very few exceptions gave the object its appropriate name, and continued looking, smilingly, at the form until the curtain was closed after a five seconds exposure. After about the third trial, several of the children would look at the object for three seconds, and then look intermittently at the experimenter and the form. At any time during the presentation of the stimulus, some children

would ask such a question as "How do you open it?", "Where is the string you pull it with?", "Why do you put a cat there?", "Let me open it," "Where does the light come from?", or "Let me see it dark." Most children, however, did not deviate from the prototype: naming the object as soon as it was seen, and looking at the object during the entire exposure period.

When the six forms from which the child was to choose the one he had seen the previous time were placed on the table, the behavior was a little more varied for individual children. The usual response was, "This one," or naming the block and pointing to it. Most of the children pointed to a block immediately, and exhibited no less hesitancy when the response was incorrect than when it was the form they had actually seen the last time in the box. Several of the children hesitated in choosing, saying, "Let me think now," and after a short pause would usually point to the correct form. A few of the children did not remember, and did not select a form.

Quantitative results. A clear concept may be gained of the children's responses by a quantitative consideration of the results obtained. In tabulating the frequencies for the various responses to each of the six stimuli, the most striking fact about the data was the great number of incorrect responses. The percentage of each type of response given to each stimulus is presented in table 8.

It may be noted from this table that the only stimulus which was responded to correctly in any way approaching half of the times it was given as a stimulus, was the kiddie car. This form was used in the first trial on delay, and both because the first trial in a new situation appears to have the greatest mnemonic value and because there were no conflicting previous stimuli to influence the choice, there were more correct responses to the kiddie car than to any of the other stimuli used. The test for determining the familiarity of the forms was given at least one month previous to the first trial with a delay, and since at that time so many forms had been seen, there was little possibility of the memory for any one of them to have been sufficiently great to obliterate a much more recent stimulus viewed with greater attention. After

the first trial, there was a marked tendency to choose the kiddie car, despite several intervening stimuli. It was noted, further, that when there was any marked hesitancy in the response, the child usually chose the kiddie car or the cat, which was responded to accurately in the next largest proportion of cases, and which was used in the second delayed response trial. On the fourth trial, child 20, when the experimenter asked him to point to the one he had seen the last time in the box, said, "I can show you everyone of them." Undoubtedly, the rather frequent succession of stimuli, and seeing the six blocks used at all of the response parts of the trials tended to confuse the child, and to

TABLE 8

The frequencies of the stimuli and the responses in percentages for the various blocks in Experiment II

STIMULUS	TOTAL NUMBER OF TRIALS	RESPONSES IN PER CENT OF THE TOTAL						
		Kiddie car	Cat	Boy	Rabbit	Pig	Auto	None
Kiddie car	28	**46.4**	17.9	21.4	7.1	7.1		
Cat	29	27.6	**38.0**		10.3	6.9	10.3	6.9
Boy	23	13.1	17.3	**26.1**	8.7	13.1	17.3	4.4
Rabbit	20	5.0	25.0	10.0	**35.0**	10.0	10.0	5.0
Pig	14	21.5	35.7	7.1		**21.5**	7.1	7.1
Auto	6	16.7		16.7		50.0	**16.7**	
Totals	120	24.2	25.0	13.3	11.7	12.5	9.2	4.2

make him unable to discriminate between the one form seen the previous time, and ones that had been seen at one time or another previous to the present trial.

This confusion was seriously aggravated by the short intervals between trials in comparison to the lengths of the delays used. The two children who were given preliminary trials in memory for these forms were, apparently, little disturbed by the conflict due to frequent stimulation, so that in generalizing from their reactions to the experiment, the necessity of long intervals between the response for one trial and the stimulus for the succeeding one was underestimated.

The predominance of negative results in the memory for famil-

iar forms was due to the inability to discriminate the last stimulus object from other forms seen, but this could have been obviated to a great extent by increasing the intervals between the trials. The proportion of correct and incorrect responses in relation to the length of the interval between trials may be seen from table 9.

From the original data it was gathered, that only in the shorter delays were the intervals between the trials considerably longer than the delays. For the delays over ten days, practically all of the intervals were less than one-half of the length of the succeeding delays. Due to the tendency mentioned previously to

TABLE 9

The proportion of correct and incorrect responses for various ratios of the interval between trials to the length of the succeeding delay in Experiment II

INTERVAL ÷ LENGTH OF SUCCEEDING DELAY	NUMBER OF RESPONSES	PER CENT CORRECT	PER CENT INCORRECT	PER CENT OF WHOLE GROUP
0.0–0.4	50	34.0	66.0	53.9
0.5–0.9	12	25.0	75.0	12.9
1.0–2.9	11	36.4	63.6	11.8
3.0–9.9	7	14.3	85.7	7.5
10.0–19.9	7		100.0	7.5
20 and over	6		100.0	6.4
Totals.....	93	26.9	73.1	100.0
First trial....	27			

remember *a* block previously seen rather than *the* block seen in the present trial, these intervals were obviously of insufficient length to obtain reliable values for the length of the delay possible for individual children.

The incorrect responses, however, increase with the increasing ratios of the interval between trials to the length of the succeeding delay. This would appear to be contrary to expectation, if the confusion among stimuli and hence the incorrect response is taken to be a result of this low ratio. This increase is due to the length of the delays included in the various groups. The higher ratios predominated in the shorter delays. These were given to

the younger children who failed to make more than a few correct responses. The nature of the responses after various periods of delay may be gathered from table 10.

Approximately one-third of all of the delay trials were responded to correctly, the remaining two-thirds, incorrectly. There was little difference in the length of the delays used as to the proportion of success in the responses, but this has no significance apart from the fact that it indicates that the delays determined upon were too long for all of the subjects in the experiment, and under the circumstances which the trials were given.

TABLE 10

The proportion of correct and incorrect responses after various periods of delay in Experiment II

LENGTH OF DELAY	NUMBER OF RESPONSES	PER CENT CORRECT	PER CENT INCORRECT
days			
1–3	33	30.3	69.7
4–9	10	40.0	60.0
10–14	47	37.5	62.5
15–20	12	41.7	58.3
21–29	10		100.0
30 and over	8	37.5	62.5
Totals.....	120	30.0	70.0

The inadequate number of cases included, and the conflicting results obtained in this experiment do not permit of many generalizations. The method used, with some modifications, would lend itself well to measuring the delayed responses, especially of the younger children. The method of reaction could be taught, and if proper intervals were introduced between trials, the results would indicate the length of time that a child could remember certain forms. A comparison could be made of the comparative ease of naming a block seen, and selecting it from a group of stimulus objects.

Case studies. The records of individual children are not as valuable in this experiment as in the experiment with the hiding of the animal cookies. However, cases have been selected which

illustrate correct memory after relatively long delays, inability to distinguish immediately preceding and other previous stimuli, and typical reactions of a child unable to comprehend the purpose of the experiment.

Child 21

This little boy cooperated very well in all of the experiments, seemingly making a great effort to remember the stimulus given. He made an accurate response in all of the four trials given him, obtaining a maximum delay of 34 days when he was 59 months old, with a mental age of 88 months. He looked very closely at the object in the exposure box, in the first trial, and smiled when the curtain was closed. In the fourth trial, when he was brought into the room for the stimulus, he said, "I know what it is going to be." After he had been shown the form he smiled, nodded his head and said, "I knew, I knew." In this instance he was referring to the stimulus to be shown to him in the box, not to any definite stimulus object. In the responses after the first trial, he showed a slight hesitancy in choosing the object he had seen, but in each case he made a correct selection. In the second trial he said, "I've forgotten which one it was," but after a pause pointed to the cat. The experimenter said, "That's fine," and he replied, "I thought that was the one." In the next trial, he looked at the forms on the table a little while, and then pointed to the correct form, voicing at this time no uncertainty in his choice. In the last trial, he said, "I don't see it," but looked at all of the blocks again, and pointed to the correct block saying, "I think this is it, but I'm not sure." He displayed a critical ability in his selections far superior to the average child of his age. His concentration upon the stimulus, and his high intellectual level account for his ability to remember the object seen longer than any of the other children tested. The fact that he was able to select the correct forms in spite of rather frequent trials and inadequate intervals indicates further, his excellent ability to make this type of delayed response.

Child 32

This case illustrates, very well, the perseverative effect of previous stimuli and responses. In the first trial, he looked at the box during the entire five seconds of the stimulus time, saying nothing to the experimenter. After one day, he pointed to the correct form immediately, offering no comments whatever at this time. The next day, he was

shown another form, and upon seeing this he said, "What did you put a cat in this time for?" After a 17 day interval, in the response situation he pointed immediately to the kiddie car, which had been the correct response in the previous trial. Unquestionably, the object of the stimulus and the response in the previous trial had a greater mnemonic value for this child than the single stimulus, especially since there was an interval of only one day between the response of the first trial and the stimulus for the second. In the third trial, he responded correctly after an interval of 14 days, at which time he was 51 months old, and had a mental age of 58 months. When shown a rabbit he said, "Isn't that cute?", and when shown the auto said, "That's a cute thing. That is better than anything else." He did not make an accurate response in

FIG. 6. PRESENTATION OF STIMULUS IN EXPERIMENT II

FIG. 7. RESPONSE IN EXPERIMENT II

either of these two trials. In the last trial he unhesitatingly chose the kiddie car. The first stimulus was certainly the dominant one of all those given.

This child is looking at the auto in the exposure box in figure 6, and shown handing the car to the experimenter in figure 7. When these pictures were taken, the child was asked to give the object he had seen in the box to the experimenter, in order to obtain a better picture of the form he selected.

This child's mother reported that this game was played at home with the child acting as the experimenter, and the mother as the subject. These directions were given, "Do you see these marbles, and see this marble in my hand? Now you show me one just like it." There was not any like it, so the child said, "Just pretend they are alike."

Child 55

Although this child could point to and name accurately the six forms used in this experiment, he was very much confused in his responses to the absent stimuli after short periods of delay. The fact that he said, "This one," and picked up the correct form in the first trial, showed that he could remember the object after one day, provided there were no conflicting stimuli. He appeared to have a preference for the pig, pointing to it incorrectly in three successive trials. He responded incorrectly with boy in the following trial. His language ability is well illustrated by this sentence spoken to the experimenter when he met her in the hall, "I am bringing this picture downstairs for Miss K.—'s children." A pig was shown in the next trial, and after two hours he was brought back to the room for the response. He was asked, "What did you see in the box today?" and after a little pause he answered, "Pig." The objects were then disclosed by removing a cloth cover which had been placed on the table over the forms, and he was asked to point to the one he had seen in the box. He then pointed to the cat, and the kiddie car, and when the experimenter said, "I thought you said that you saw a little pig," he pointed to the rabbit. In the response for the following trial, he pointed to the pig, which was incorrect for this trial. This record demonstrates the great difficulty of a multiple choice situation for the younger children, since there are so many conflicting elements in the whole pattern of stimulation.

Summary. Delayed responses to exposures of familiar forms were obtained on 27 children who were given a total of 120 trials. The proportion of stimuli responded to correctly after an interval of time had elapsed since their presentation varied from 46.4 per cent in the case of the kiddie car, to 16.7 per cent when the auto was used as the stimulus. Seventy per cent of the stimuli given were responded to incorrectly after the delays introduced. This percentage differs little for the various lengths of the delays tried. The increase in the proportion of incorrect responses as the ratio of the interval between the trials to the length of the succeeding delay increases is misleading. The trend in these percentages is due to the nature of the length of the delay periods included in the different groups, not to this increasing ratio. The conflicting effects of previous stimuli and the immediately preceding stimulus seriously detracted from the reliability of the

delayed responses obtained in this experiment. The anticipated difficulty of this multiple choice situation using familiar forms as stimuli was not realized, because the maximum delays obtained had exactly the same range, namely one to 34 days, as those in experiment I, where delayed responses were made to the position of a concealed object. The confusion of the stimuli given in successive trials, and the complications introduced by the language associations involved, necessitated a further modification of this method in order to secure ever shorter maximum periods of delay and to avoid the effects of the marked perseverative tendency manifested in so many of the delayed responses in this set-up. The applicability of the general procedure, however, led to the choice of geometric forms as stimuli, since these were assumed to be more difficult to distinguish and remember than the familiar forms employed.

III. Delayed responses to exposures of geometric forms

Experimental procedure. The same apparatus was used in this experiment as in the preceding one, except that the test objects in this case were geometric forms, the names of which appeared to be unfamiliar to the age groups tested. The materials for this experiment are illustrated in figures 8 and 9. The six forms: square, triangle, diamond, cross, star, and circle, were chosen because they could be matched by the subjects of this experiment, in a preliminary test like the one in which familiar forms were used, but this time the children were not asked to name the blocks. It developed, however, that the children tended to give names to the forms according to an object that had a similar contour, and that a few of the children even knew the appropriate names for several of the forms. Both the presentation of the stimulus and the procedure for the delayed response were identical with those in the second experiment. Each block was shown, in a certain sequence in successive trials, in the large exposure box for 5 seconds. After a predetermined period of delay the child was brought back into the room and asked to point to the block he had seen in the box the last time. For the response the six geometric figures used in this experiment were placed directly in

front of the child on a small table, in an irregular order for consecutive trials. Following the conclusion of this experiment each child was asked to name the six blocks, and in case he responded, "Don't know," he was asked what it looked like, in order to determine, at least partially, the importance of the associative factor in the memory for the forms seen. In this test, the position of the form chosen in the response was also recorded, in order to provide a check on the frequency with which each posi-

FIG. 8. APPARATUS FOR STIMULUS PRESENTATION IN EXPERIMENT III

tion was chosen, and to determine whether or not there was any preference for any of these.

Children's behavior during the experiment. In selecting geometric forms for stimuli instead of the more familiar objects used in the second experiment, it was assumed that the geometric forms would have less associations and hence could not be remembered for a very long time. The assumption proved to be true to a very great extent, since there was less tendency to name the blocks as they were shown in the exposure box, and no child

made a correct response if more than four days elapsed between the presentation of the stimulus and the response.

Since most of the children in this experiment had been subjects in the experiment with familiar forms, using the same exposure box, little curiosity was evinced regarding its operation when the geometric figures were used. Several children remarked about the change in the type of stimuli used. One child said, "I

FIG. 9. APPARATUS FOR RESPONSE IN EXPERIMENT III

thought it was a cat in there," and another child in the ninth trial with the geometric forms said, "Where are all the animals?"

Most of the children did not deviate from the following behavior in any of the trials. When the stimulus was shown, the child smiled, nodded his head or pointed to the form in the exposure box, continuing to look at it all of the time that the curtain was open. When responding, these children merely pointed to a block without giving any vocal response, or occasionally one would say, "This one," or name the form as he pointed to it.

In contrast with the behavior in the second experiment, there was little naming of the stimulus objects. A few of the children when viewing the stimulus object in the box, put their elbows on the table and rested their faces in their hands as if to concentrate better on the form. Typical individual differences in reacting to this experiment will be discussed in the analysis of special cases.

Quantitative results. Since more trials were given, and stricter attention was paid to the intervals between trials in this set-up than in the one with the familiar forms, the statistical analysis of the delayed responses to geometric figures is of greater value. The proportion of each type of response made in the

TABLE 11

The frequencies of the stimuli and the responses in percentages for the various forms in Experiment III

STIMULUS	TOTAL NUMBER OF TRIALS	RESPONSES IN PER CENT OF THE TOTAL						
		Square	Circle	Tri-angle	Cross	Star	Dia-mond	None
Square	52	**63.5**	15.4	3.9	13.4	1.9	1.9	
Circle	54	7.4	**68.5**	5.6	3.7	7.4	7.4	
Triangle	39	5.2	12.8	**58.9**	2.6	2.6	17.9	
Cross	39	12.8	5.2	2.6	**56.3**	5.2	17.9	
Star	36	5.6	8.3	13.9	13.9	**44.4**	8.3	5.6
Diamond	22	4.5	18.2	9.1		4.5	**63.7**	
Totals	242	19.4	24.4	14.9	15.3	10.3	14.9	0.8

trials when the different forms were used as the stimulus is given in table 11.

It will be seen that there was some confusion in discriminating between all of the blocks, due to inaccurate memory of the block seen the previous time in the exposure box. A great many of the erroneous responses were made to the triangle, cross, star, and diamond, since these were used as stimuli in the later trials, when longer delays were used, and the tendency to perseverative responses had a more appreciable effect. Aside from this effect due to previous stimuli and responses, there was a measurable failure to distinguish accurately between the square and the cross, the triangle and the diamond.

In order to discover individual differences in the familiarity of these geometric forms used, after all of the delay trials had been completed, each child was asked to name the blocks, the experimenter asking, "What is this?" as she pointed to each block lying upon the table. Since all of the children had matched the forms accurately in a preliminary test for familiarity, there was no question as to their ability to discriminate the forms. The three blocks given their appropriate names the most frequently were the star, square, and circle. Whereas the star was usually called a "star," the square was given such names as "table top," or "brick," about as frequently as it was called a "square," and the circle was often called a "moon," "ball," "wheel," or "ring," any one of which indicates that the form had some associative value for the child. The triangle was sometimes called a "house," or a "Christmas tree," the cross a "windmill," or a star with certain qualifications, and the diamond everything from a "fish" to "four squares."

The ability to name the forms does not correspond absolutely to the ability to remember them. In order to have tested the correlation, the forms would have had to be given in a different sequence for each child so as to test the memory for each form after various lengths of delay. As it was, the results in table 11 indicate that the star, which was used in the longer delays and was also named accurately in the most instances, was responded to correctly in the smallest proportion of the total number of times it was given as a stimulus. Since the diamond and the star were both used primarily in the longer delays, it is impossible to account for this difference in their associative values as determined by the children's ability to name these forms. It is further impossible to determine whether or not the high proportion of correct responses to the circle and the square was due to their familiarity or to the fact that they were used in the shorter delays. The solution of this problem, the relation of the familiarity of a form to the length of time that it can be remembered, is one which requires further study. The difficulty and hesitancy with which the geometric figures were named as an indication of their associative value, in contrast to the ease with which the

familiar forms in the second experiment were named, undoubtedly accounts in a large part for the great differences in memory for this type of stimulus.

A survey of the incorrect responses made when the geometric forms were used as stimuli yielded the results given in table 12.

The tendency to choose the form responded to in the previous trial was not as great as the tendency to respond to the plate where the animal cookie had been found in the previous trial in the first experiment. Although there was a noticeable influence of the previous response upon the present one, the primary reason for its not being more marked was that the response in the experiment with the geometric forms, with the choice from a sample, was not recognized as right or wrong by the child, and

TABLE 12

An analysis of the incorrect responses made in Experiment III

INFLUENCING FACTORS IN THE 97 INCORRECT RESPONSES	PER CENT
Form responded to in previous trial	33.0
Position responded to in previous trial	13.4
Seen or responded to at some previous time	23.7
Seen at the previous trial	9.3
Not seen or responded to before	18.5
No response made	2.1

that there was no reward given for a correct response, which would tend to increase the intensity of the stimulus. Only 20 per cent of all of the responses were made to a form neither seen or responded to in some previous trial. In the later trials there appeared to be a greater inability to make a correct delayed response, when it became increasingly difficult for the child to distinguish between several recent stimuli and the most recent one. Occasionally, an incorrect response was made which would have been correct in the previous trial, which trial had also been responded to incorrectly. It is possible that the child might have remembered that he had seen that block and did not remember having pointed to it in any response trial, and hence pointed to it in this last trial in spite of a later stimulus.

The six blocks for the response were placed on the table in front of the child, in two rows and were numbered from left to right in each row. There was manifested, on the part of some of the children, a distinct tendency to point to the block in the same relative position to the others as the block pointed to in the previous trial or trials. Whether this was a motor habit, a motor memory, or simply a convenient place to point to in case the form shown had been forgotten, it is difficult to say except in a study of individual cases.

The proportion of correct and incorrect responses to the various positions is given in table 13. In this table, as well as in all of the others, in the few cases where more than one form was

TABLE 13

The proportion of correct and incorrect responses for the various positions in Experiment III

POSITIONS	TOTAL NUMBER	PER CENT CORRECT	PER CENT INCORRECT
No response	2		100.0
1	41	70.7	29.3
2	49	69.4	30.6
3	46	78.3	21.7
4	39	66.7	33.3
5	36	25.0	75.0
6	29	38.0	62.0
Totals.....	242	59.9	40.1

pointed to, only the first selection was considered in order to avoid duplication in the tabulations.

When the forms in positions one, two, three, and four were responded to, the selections were correct in over two-thirds of the trials in each case. On the contrary, when the forms in positions five and six were pointed to, the responses were incorrect in 75 and 62 per cent of the trials respectively. The tendency to point to these positions was noted in the early trials, and in order to avoid as much as possible the selection of the correct form because it was placed in the most favorable position, and increase the child's probability of making a correct response without memory for the form seen in this trial, these two positions were

used very little as the position for the form which was the correct response. The tendency to point to these forms which were nearest to the subject and readily accessible to his right hand might easily be explained on the basis that they were the most convenient responses, position five being more so than position six.

In this experiment the trials were spaced more in accordance with the lengths of the delays used than in the two previous ones. The maintaining of a large ratio of the interval between trials to the length of the succeeding delay was more closely adhered to in the shorter delays than in the longer ones, however. In

TABLE 14

The proportion of correct and incorrect responses for various ratios of the interval between trials to the length of the succeeding delay in Experiment III

INTERVAL ÷ LENGTH OF SUCCEEDING DELAY	NUMBER OF RESPONSES	PER CENT CORRECT	PER CENT INCORRECT	PER CENT OF WHOLE GROUP
0.0–0.9	21	23.8	76.2	10.3
1.0–2.9	32	34.4	65.6	15.6
3.0–9.9	33	60.6	39.4	16.1
10.0–19.9	14	64.3	35.7	6.8
20 and over	105	68.5	31.5	51.2
Totals.....	205	57.1	42.5	100.0
First trial....	37			

table 14, are given the proportions of correct responses for the various ratios of the interval between trials to the length of the delay.

With increasing ratios, the proportion of correct responses increases from 23.8 per cent when the ratio is less than one, to 68.5 per cent when the ratio is over 20, that is the interval between the trials is over 20 times the length of the succeeding delay. This increase in the percentage of correct responses is due not only to the increased interval between the trials, lessening the perseverative effect of previous stimuli and responses, but also to the greater number of correct responses in delays of less

than one day, which are also the delays that are preceded by the comparatively long intervals. Unless the ratios are approximately constant for various lengths of delays, it is not possible to determine their effect upon the nature of the responses.

About one-tenth of the intervals were less than the length of the succeeding delays, while about three-fourths of the intervals were over three times the length of these delays. In over one-half of the trials, the intervals were more than 20 times the lengths of the delays after the interval used in computing the ratio.

The proportion of responses that were correct after various periods of delay is given in table 15.

TABLE 15

The proportion of correct and incorrect responses after various periods of delay in Experiment III

LENGTH OF DELAY	NUMBER OF RESPONSES	PER CENT CORRECT	PER CENT INCORRECT
0–59 minutes	105	52.9	47.1
60–119 minutes	35	88.5	11.5
2–5 hours	19	94.4	5.6
1 day	23	56.6	43.4
2 days	39	33.3	66.7
3 days	7	28.6	71.4
4 days	9	44.4	55.6
5 days and over	5		100.0
Totals.....	242	59.9	40.1

No consistency is portrayed in the change in the percentages of correct responses after various periods of delay. It is necessary to consider each group by itself, since the trials included in each largely account for the percentages obtained. In the first group are included the trials of several children who failed on almost all of the delays given, all of which were less than one hour. Also many of the responses in the first trial, in which the delays were usually very short, were incorrect because the child had not quite understood the experiment. In the later trials, when the delays were much longer than one hour, correct responses were made by many of these children. In the delays of from one to five hours are included the trials on those children who both could and could

not remember a day, but could remember longer than one hour. If a child could remember one hour, it was probable that he could respond correctly at any later time during that same day, although he might not be able to respond correctly the next day. The children whose maximum delays fell within the range of from one to five hours could, perhaps, have remembered several hours longer, but due to the nature of the nursery school hours, the variety of the delays used was considerably limited. The percentage of correct responses decreases with the increasing length of the delays with the exception of the four day delay. However, the groups above two days, included too few trials to permit of any generalizations. None of the children in the group tested could respond correctly if a delay of more than four days was introduced between the presentation of the stimulus and the response.

Case studies. In non of the four experiments was so much variety displayed as in the reactions to this experiment. The cases selected illustrate responses to the situation using geometric forms as stimuli, types of comments made during the experiment as an evidence of the understanding of the situation, the perseverational effect of a previous correct response or a previously responded position, the naming of all the stimulus objects as they were presented, and the inability to understand the purpose of the experiment.

Child 21

The record for this child is typical for approximately half of the children used as subjects in this experiment. In the eight trials given with geometric forms as stimuli, he did not deviate from the following behavior, except in minor details: looking at the form, smiling, and nodding his head when the stimulus was given, and likewise in the response situation, pointing immediately to one form with no comments. He obtained a maximum delay of two days when he was 61 months old and had a mental age of 90 months. When asked how he remembered these forms he said, "I look at them a while, then I think about them so that I can remember them."

This child is shown looking at the triangle in figure 10. In figure 11 he is giving the block to the experimenter rather than pointing to it, as

was requested in the regular experiments, because it was thought that the selected block would be more clearly shown in the picture.

Child 33

No child expressed his ideas about the experiment as freely as did this boy. When he was shown a square in the first trial he said, "Block. I used to play a different game with little rabbits and all kinds of toys. Now it's different." He responded correctly after a delay of 30 minutes saying as he pointed to each block on the table, in turn, "Next time one like this, and this, and this. The star is almost like a cross except that they are different. I know what a star is. Is there one in there?" as he pointed to the exposure box. When the circle was shown him he

FIG. 10. PRESENTATION OF STIMULUS IN EXPERIMENT III

FIG. 11. RESPONSE IN EXPERIMENT III

said, "Moon. A moon's like a circle isn't it?" In the response he pointed to the circle and then picked it up, waving it about before placing it back on the table. When he was shown a cross, he called it a "square," but said, "No, this way and that," as he motioned his hands like a cross. After having responded accurately with a square in the last trial, he placed the corner of the square to fit in between the intersections of the cross and said, "Look, they fit like this." His maximum delay of 4 days was obtained when he was 54 months old and had a mental age of 66 months. His vocal responses, unquestionably, strengthened the stimulus and enabled him to respond after longer periods of delay than most of the other children.

Child 23

This child responded correctly in all delays attempted up through four days. His behavior was practically the same as that described for child 21 on page 56, except that this child did not nod his head when the stimulus was shown. This case is described because it gives an excellent illustration of the perseverative effect of a previous response. In the sixth trial, he responded correctly after a four day delay by pointing to the square, when he was 59 months old. Three days later he was given the circle as a stimulus. In the response to this trial, after a delay of five days, he pointed very slowly to the square. The interval between the trials had been too short for the intervening stimulus to overbalance the mnemonic value of the stimulus and the response in the preceding trial. The hesitancy in the choice of this last trial was in marked contrast to the immediate selections in all of the previous trials.

Child 47

This was the only child who showed a consistent tendency to respond incorrectly to the same position each time. She looked closely at the form each time that the stimulus was given, but pointed to the block in position five in the first four trials, regardless of the form that was placed there. In the fifth trial, she responded correctly after a five second delay. Six days later, she resumed her response to the form in position five after a five minute delay, but changed her choice and pointed to the form in position one, which was the correct response for that trial. In the next trial, she pointed smilingly to the correct block which was in position four, having then gained an understanding of the test. It was unfortunate that no further trials could be obtained on this child due to her absence for the remainder of the experimental period.

Child 43

This record is illustrative of the attempt made to name all of the forms seen, even though this performance was not requested. She named all of the familiar forms when they were presented as stimuli in the second experiment, which reaction was probably carried over to this situation with the geometric figures. A triangle was called a "Christmas tree." When she was shown the circle she said, "A nice little, nice little, nice little," the curtain was closed and she added, "thing wasn't it? It was a moon wasn't it?" The best thing she could call the square was, "A little, a little air." When asked to name the

square in the final familiarity test she called it "sky." A cross was designated as a "butterfly," a star a "scramble," and a diamond a "house," when these were used as stimuli. She responded correctly to the star after a delay of two days, when she was 46 months old, and had a mental age of 62 months.

Child 24

This child likewise manifested a tendency to name each form, but her expression took a somewhat different turn than those described for child 43. When given the first trial she said, "I want to stand this time," and as she left the room, "What's that down there?" pointing to the back stairway. A circle was called a "round one." When she was shown a cross she said, "Round one. It isn't, but I didn't know it so I said round one." In the response on this trial, she entered the room before the experimenter and upon seeing the blocks on the table, pointed to the correct block before the directions for the response were given saying, "I saw this one. I pointed before you knew it, didn't I?" When she saw a square she said, "It's a whole one. I couldn't tell you, so I said a whole one," and when a diamond was shown to her she said, "Round. It's different, but I don't know so I said round." In this last trial she pointed incorrectly to the circle saying, "I didn't know it." It seems very probable that calling the object round, even though at the time she recognized that it was not round, confused her thinking and made her point to the round one instead of the one she had seen in the previous trial. When she made a correct response to the star after a two day delay when she was 59 months old with a mental age of 69 months, she said to the experimenter's "That's right," "How do you know if I get it right?" The experimenter had unwittingly said "right" instead of "fine." She was answered that the experimenter had it written down. She pointed to the blocks on the table and said, "Sometimes it is this, and this, and this," as she pointed to the triangle, the star, and the square. From her expressions it appeared that she had a better conception of the experiment as a whole and its purposes than any of the other subjects.

Child 52

This was the youngest child used in the experiment. Although he could match all of the forms in the preliminary trial, he failed to respond correctly in all but one trial, and the accurate response in this case was undoubtedly due to chance. His behavior was not different from that

displayed by any of the other children either in the presentation of the stimulus or in pointing to the form in the response, but his responses were invariably incorrect. Only a partial explanation can be given of this failure. The curtain to the box was opened, and he was asked to show the experimenter one just like the form in the box. He pointed to several saying, "This one, this one, and this one." The experimenter said, "But which one is most like the block in the box?" He pointed immediately to the correct form. In the following trial, however, when he was asked to point to the block the most like the one he had seen in the box he made an incorrect response. If more trials could have been given to this child, it is very probable that he would have learned to make the correct response in spite of the consistent early failures. When he was asked to name the forms after the last delay trial, he called most of them blocks, and when asked what kind of blocks he said, "To look at." He placed the star over the edge of the triangle and said, "This is a horse riding on a man." He called the star, further, a "goose," one of the points being designated as the "hanger." His record gives an inadequate basis for further interpretation of his continued failure to respond correctly in this situation after very brief delays.

Child 49

This child displayed some understanding of the test, but his reactions were incorrect in a majority of the trials. Although he responded correctly in three out of the first six trials, he did not respond correctly in any of the following nine trials, in spite of delays of similar length. The maximum delay obtained for him was ten minutes, using the star as a stimulus, when he was 46 months old. Since the trials were well spaced, and the child could match each of the forms correctly in both the preliminary and final familiarity test, the only explanation that can be offered, especially in the light of the correct response in the earlier trials, is that the child became so confused when he was given a great many trials that he could not remember the order of the stimuli. He was always eager to come with the experimenter, usually laughing heartily each time that the stimulus object was exposed in the box. It was not until the fifteenth trial that he showed any curiosity concerning the operation of the exposure box, "Have you got a rubber band in there to pull?" In the last trial, he asked to put his finger in the box, and when he was permitted to do so, he went up to the box, pounded at the square, and then said, "What's attached on there?" He seemed surprised that

it had not fallen out. This child would certainly have profited by a training series beginning with shorter delays always responded to correctly, and increasing to longer ones.

Summary. Delayed responses to exposures of geometric forms were obtained on 37 children who were given a total of 242 trials. The stimulus responded to correctly in the greatest proportion of trials was the circle, and in the least proportion, the star. This was not due, primarily, to differences in the familiarity of the two forms or in ability to discriminate between these and the other forms employed, but to the fact that the circle was used in the shorter delays, and hence was remembered in more cases than the star, which was used in the longer delays. There was less tendency to respond to the block or position responded to in the immediately preceding trial than was noticed when familiar forms were used as stimuli. This was due, undoubtedly, to the longer intervals between trials than was the case in the second experiment. The blocks in the two positions immediately in front of the child, and to his extreme lower right were pointed to incorrectly in the majority of the trials, whereas when any of the four other positions were pointed to, the response was correct in over two-thirds of the trials included in each group. About three-fifths of all of the stimuli given were responded to correctly in this experiment. There was a distinct increase in the proportion of these correct responses when the interval between trials in relation to the succeeding delay was large. The studies of individual children illustrate typical and exceptional delayed responses to geometric forms.

The maximum delays obtained in this experiment, ranging from ten minutes to four days were about one-tenth as great as those obtained in the two previous experiments, but this decrease was not as great as that desired. Since the decreased familiarity of these forms undoubtedly accounted in a large part for the decrease in the period of the maximum delays obtained, it was believed that if forms having even less associative value were selected, the delays could be further decreased.

IV. Delayed responses to exposures of unfamiliar forms

Experimental procedure. Six symbols were chosen for stimuli from those used in the Johns Hopkins substitution tests, because they could not be appropriately named by either adults or children. Each of the six figures were pasted on a card $3\frac{1}{2}$ by 3 inches. For the response situation, the six forms, each used at different times as the stimulus, were pasted on a card 5 by 8 inches, in two rows about two inches apart. A response card is reproduced in figure 12. Three of these response cards were made in order to place the figures in a different arrangement for

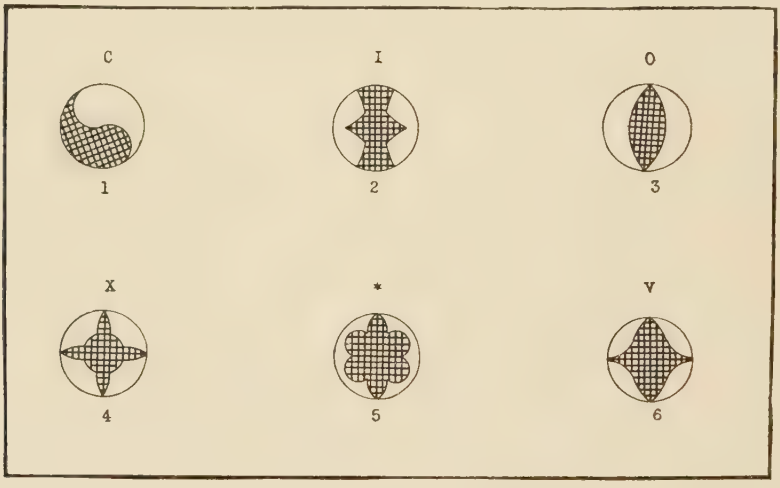

Fig. 12. Response Card for Experiment IV

each trial. Each of the symbols was given a letter or figure somewhat similar in its contour as indicated on the response card on this page, and will be referred to as such in the tables and discussion. Although appropriate names do exist for these forms, they would have less associative value than suggestive letters and figures, so that they have not been included here. In the preliminary experiment, all of the children who were given this situation could point to the correct symbol when the card was held directly in front of them. (Only the children above three years old were included in this experiment.) In many cases,

however, the response was not as immediate as in the second and third experiments, since the children frequently looked back at the figure to be matched, in order to discriminate accurately between the various forms.

For the presentation of the stimulus, the subject was seated in front of a small table on which was placed a Whipple portable tachistoscope. The same verbal directions were used as those in experiments II and III. The shutter was opened by the experimenter who stood in back of the table facing the child, and was closed after 5 seconds. After a period of delay the child was brought back into the room, and seated in front of the table on which the closed tachistoscope was placed. This time, the large card containing the six symbols used in this experiment was placed in front of the box, and the child was asked to point to the figure he had seen in the box. After all of the trials had been completed, each child was asked to tell what each figure looked like, or of what it made him think. There was a marked hesitancy in naming these figures, in many cases the children responded, "Don't know," to several questions regarding the appearance of the forms. Their paucity of verbal and experiential associations undoubtedly accounts for the short length of time that these figures could be remembered by the majority of the children. This experiment lends itself better to the measurement of the effects of training and increased familiarity with the stimuli than any of the previous ones.

The anticipated difficulty of remembering these forms was not completely justified in the results obtained. The delays were much longer than those expected, and the behavior manifested was little different from that in the two previous experiments using the familiar and geometric forms as stimuli.

A great deal of curiosity was shown concerning the Whipple portable tachistoscope, which was used for exposing the stimulus symbol or form. Several of the children asked "to do it" or "to open the shade." Many of the children were a little startled the first time the shutter was opened, because of the noise made, but this did not disturb them in the subsequent trials. There was much less tendency to name the forms used than in the two

previous experiments. The usual behavior when the stimulus was shown was to point to it, or remain looking at it without any overt response, and simply pointing to the symbol in the response saying, "This one," to the question, "Which one did you see in this box the last time you were in here?"

Quantitative results. The proportion of the different responses to the various symbols used as stimuli in this experiment is given in table 16. The symbols to which the keys refer may be seen in the response card on page 62.

The number of times that each symbol was used as a stimulus was not very large for any one of them, but the proportions reveal some interesting features for further study. The two forms

TABLE 16

The frequencies of the stimuli and the response in percentages for the various symbols in Experiment IV

STIMULUS	TOTAL NUMBER OF TRIALS	RESPONSES IN PER CENT OF THE TOTAL					
		I	X	V	*	C	O
I	32	**62.6**	6.2	3.1	12.5	6.2	9.4
X	30		**80.0**	10.0		3.3	6.7
V	14		7.1	**50.0**	14.3	21.4	7.1
*	22		31.8	13.7	**45.5**	4.5	4.5
C	14			7.1	7.1	**85.7**	
O	9	22.2	11.1			22.2	**44.4**
Totals.....	121	18.2	28.9	12.4	14.0	17.3	9.1

responded to accurately in over 80 per cent of the cases were the X and C. The ones remembered the least frequently were the O and the *. The O was used in the longer delays and was, therefore, frequently responded to incorrectly, but the primary reason for the larger proportion of incorrect responses to the * was due to the difficulty of discriminating between it and the X. In the final test for determining the familiarity of these forms, each child was asked to name the symbols, and in case he responded, "Don't know," he was asked to tell what each form looked like. The hesitancy in naming and the refusal to name the forms at all in many cases, illustrated quite conclusively,

that naming the symbols played a very small part in the memory for them. The only two forms which were named appropriately, were the C, which was given names such as moon, bowl, snail, and top of a baby carriage, and the X, which was called a switch, airplane, windmill, cross, a star with a ball around it, and a pin wheel. This ability to name, together with the ease of discriminating these forms, accounts for the greater proportion of correct responses for these two stimuli than for any of the other four. Many of the children responded, "Don't know," to one or more of the stimuli saying, "I think it looks like something, but I can't name it," "I can't because I haven't seen it enough times," "They look like something, but I don't know what," or "They don't look like anything." Several children in attempting to name each symbol sometimes gave the same name to two of the forms. When this occurred, they were asked, "Are those the same?" and if the child aswered, "No," he was asked, "Then how are they different?" In most cases they responded, "Don't know," or "They aren't different," although they were able to match the two forms given the same name without the slightest hesitation. One child gave two forms the same name, but when asked if they were alike he said, "No, they are very different," but could not state any difference. Another child, in distinguishing between the V and the X, both of which she had called a "cross" said, "This (pointing to the V) has two thick and two thin, but this (pointing to the X) has all thin," referring to the projections. There was little uniformity in the names given to the other forms, although the * was called a leaf or a flower quite a number of times and the I was called a man by several of the children. The associative value of these forms was almost negligible, as was demonstrated by the children's failure or great hesitancy in naming the forms after having seen each one of them at least five times, either as a stimulus or on the response card.

The perseverative effect of the previous responses is of less importance in this experiment than in any of the other three, as may be seen from table 17.

Of the 44 incorrect responses to this experiment, only 2.3 per

cent were responses to the form in the same position as that in the previous trial. Almost two-fifths of the incorrect responses were made to a form which had not been given as a stimulus or responded to by the child before the present trial. Less than one-third of the incorrect responses were of a distinctly perseverative nature, that is, either to the form or the position responded to in the previous trial.

TABLE 17

An analysis of the incorrect responses made in Experiment IV

INFLUENCING FACTORS IN THE 44 INCORRECT RESPONSES	PER CENT
Form responded to in previous trial	27.2
Position responded to in previous trial	2.3
Form seen or responded to at some previous time	22.7
Seen in the previous trial	9.1
Not seen or responded to before	38.6

TABLE 18

The proportion of correct and incorrect responses for the various positions in Experiment IV

POSITION OF FORM SELECTED	TOTAL NUMBER	PER CENT CORRECT	PER CENT INCORRECT
1	20	50.0	50.0
2	22	54.6	45.4
3	19	68.4	31.6
4	21	76.2	23.8
5	15	40.0	60.0
6	24	83.4	16.7
Totals	121	63.7	36.3

The proportion of correct and incorrect responses to the various positions of the symbols as numbered on the response card in figure 12 on page 62, is presented in table 18.

By referring to table 18, it will be seen that there was less tendency to prefer any one position than was observed in the experiment using the large wooden geometric forms. Although there was a larger proportion of incorrect responses to the forms in position five, the difference between this percentage and the others is not great enough to be of any significance. All of the

forms for the response were on a card which was only 5 by 8 inches, so that pointing to one form required about the same amount of effort as pointing to any other one. The total proportion of trials that were responded to correctly in this situation was 63.7 per cent.

The trials in this experiment were very widely spaced for the most part, but especially for those delays which were shorter in length than one day. Very few of the trials were separated by less than the length of the succeeding delay. The proportion of correct and incorrect responses corresponding to the various ratios of the interval between trials to the length of the delays is presented in table 19.

TABLE 19

The proportion of correct and incorrect responses for various ratios of the interval between trials to the length of the succeeding delay in Experiment IV

INTERVAL ÷ LENGTH OF SUCCEEDING DELAY	NUMBER OF RESPONSES	PER CENT CORRECT	PER CENT INCORRECT	PER CENT OF WHOLE GROUP
0.0–0.9	7	71.4	28.6	7.6
1.0–2.9	10	70.0	30.0	10.8
3.0–9.9	10	80.0	20.0	10.8
10.0–19.9	3	100.0		3.2
20 and over	63	58.8	41.2	67.6
Totals.....	93	64.5	35.5	100.0
First trial....	28			

Due to the nature of the distribution of the delays in the trials included in the various ratios, the percentages of correct and incorrect responses are in themselves of little value. These ratios would seem to indicate that the longer intervals are less desirable, as far as obtaining correct responses is concerned, than the shorter intervals. To a certain extent this may be true, since it was possible that the child might forget certain elements of the experimental situation if too long a time intervened between the trials, and thus predispose him to an incorrect response. This was especially true in cases where the child failed several times on the shorter delays given, perhaps on alternate days, whereas after he had attained a better idea of the test he made

correct responses after longer delays, with shorter intervals between the trials. Less than 20 per cent of the intervals were less than three times the lengths of the succeeding delays, whereas over two-thirds of the trials were given after intervals at least 20 times the length of these delays.

The proportion of correct and incorrect responses after various periods of delay is given in table 20.

There is no constant increase or decrease in the proportion of correct responses after increasing periods of delay. In the first group the percentage is lowered a great deal by numerous failures in the first trials which were, with a few exceptions, delays of less than 30 minutes. Most of the children succeeded in the second

TABLE 20

After various periods of delay in Experiment IV, the proportion of correct and incorrect responses

LENGTH OF DELAY	NUMBER OF RESPONSES	PER CENT CORRECT	PER CENT INCORRECT
0–29 minutes	55	58.2	41.8
30–59 minutes	30	70.0	30.0
60–119 minutes	15	53.3	46.7
2–6 hours	5	100.0	
1 day	13	76.9	23.1
2 days	3	33.3	66.7
Totals.....	121	63.7	36.3

trial given of less than 30 minutes, however, and often made successful responses after delays of more than one hour as well. The delays of from two to six hours were given to children who could not remember any of these symbols for one day, but very probably could have remembered one of these figures longer than six hours, providing the nursery school's hours had permitted such delays. Only one child in the group remembered these symbols as long as two days, although several perseverative responses occurred after periods of longer duration than this.

Case studies. None of the individual records gives a great deal of data on the child's memory for the forms in this experiment. Although the symbols in themselves were not a disturbing ele-

ment, the operation of the tachistoscope and the child's interest in obtaining permission to close or open the shutter tended to detract from the value of the experiment. There appeared to be little possibility of a decrease in this interest, in fact, the children seemed more and more curious about the box in each succeeding trial. Records have been selected for a more detailed description, which illustrate the typical responses to this experiment with the unfamiliar forms as stimuli, a consistent attempt to name all of the forms seen, the behavior of a very inquisitive child, and the effect of a variation of the stimulus upon the delayed response.

FIG. 13. PRESENTATION OF STIMULUS IN EXPERIMENT IV

FIG. 14. RESPONSE IN EXPERIMENT IV

Child 29

This child's response during the whole experiment is typical for all of the children. When the stimulus was shown, she either pointed to it or simply looked at the symbol during the entire exposure time. She did not hesitate in pointing to the symbol in the response, one time even pointing to the correct form before the directions were given. Her maximum delay time was five and one-half hours, when she was 58 months old, and had a mental age of 61 months.

Child 32

A great deal of interest was manifested in this situation by this boy. He called two of the stimulus forms, "a funny thing," and "a thing that jumps." He wished to wind and open the shutter, but this was not permitted. On the second and third trials, he pointed to the correct

form before the directions for the response were given. He remembered the correct form after one day, when he was 54 months old, and had a mental age of 61 months.

The child is pictured looking at the form in figure 13, and pointing to the form seen in the tachistoscope in figure 14.

Child 43

This child was consistent in her attempt to name all of the forms seen in each of the three experiments employing forms as stimuli. When she saw the I in the tachistoscope she said, "A pretty . . . . piece of furniture." She called the X, "A b-b-building," and the *, "A sky, a house." Her maximum delay was one day when she was 49 months old and had a mental age of 62 months.

Child 27

An excellent example of a very curious and excitable child is illustrated in this case. In almost every situation in which the experimenter came in contact with this child, his chief question at all times was, "What is that?" In many cases he answered the question himself if no answer at all was forthcoming. He failed in his response on the first trial, after a delay of five minutes. Eight days later the C was given as a stimulus. When the shutter to the tachistoscope was left open and the response card was placed in front of him, he pointed to the correct form and said, "This is that." His attention now completely left the forms, and centered upon the box itself, "I want to open it." In order to study his behavior at greater length, the experimental procedure was dispensed with, and the following occurred. The experimenter wound the tachistoscope so that the last opening would occur when the lever was pushed down. The child was then permitted to close the shutter and wind the tachistoscope again. In attempting to close the shutter a second time, he turned a screw at the bottom of the box which had no connection with the shutter, but pushed the lever again, thus closing the aperture. It was only after some persuasion that the child would leave the room. When he was brought into the room two hours later he said, "I want to open it." When the directions were given he pointed immediately to the correct symbol, and turned his attention again to the tachistoscope. He was permitted to open and close the shutter as he had done two hours previously, and in doing so he saw the * which had been placed in the tachistoscope for stimulating another child. He saw this form sufficiently long so that it was regarded as a stimulus, and

justly so, because the child pointed to this form immediately one day later, when the response card was placed in front of him. Undoubtedly, the child's great attention and interest enabled him to remember the last form shown a day previously, whereas he failed in the first trial after a five minute interval. The fact that there was no interval between the response of the second trial and the stimulus for the third was more than compensated for in the type of stimulation received with the self-operation of the tachistoscope. This was not considered as a maximum delay since the stimulus pattern was very different from that given the other children, and hence the results were not comparable.

Child 16

After a maximum delay of two hours was obtained on this child when he was 65 months old and had a mental age of 82 months, the conditions of the stimulus were somewhat changed in order to see if this made any difference in the length of the delayed response. Instead of exposing the form for five seconds, the shutter in the tachistoscope was closed after one second's exposure of the form. The child remembered this form after a delay of one hour, and did not manifest any different behavior in either the stimulus or response situation than under the usual experimental conditions. It appears that if the stimulus time is long enough to give a clear picture of the form that, within certain limits, an extension of this time makes no appreciable difference.

Summary. A total of 121 delayed response trials were given to 28 children in this experiment where unfamiliar forms were shown. The I and the C (the forms which they represent may be seen in figure 12 on page 62) were each responded to correctly in over 80 per cent of the trials in which they were given as the stimulus. The final familiarity test indicated the inability to name any of the forms according to some similar object, except with a great deal of indecision and hesitancy. Less than one-third of the incorrect responses were of a perseverative nature, that is an incorrect response due to the persistance of the previous correct response. There was not such a distinct tendency to point to the forms in the positions nearest to the subject in this experiment, since all of the positions were about equally accessible. The maximum delays obtained in this test ranged from one minute to two days. No definite relationship was noted

between the ratio of the interval between trials to the length of the succeeding delay. The individual studies attempt to account, to some extent, for the great variation in the length of the maximum delays obtained by the different children.

This situation has not been adequately tested for its applicability to the measurement of delayed responses, but in view of the short delays obtained, it appears to be the type of measure desired. Suggestions for the further use of this test will be made in the final summary of this investigation.

TABLE 21

The distribution of maximum delays and chronological ages in Experiment I

MAXIMUM DELAY	CHRONOLOGICAL AGES IN MONTHS															TOTAL NUMBER
	24–26	27–29	30–32	33–35	36–38	39–41	42–44	45–47	48–50	51–53	54–56	57–59	60–62	63–65	66–68	
days																
34–36									1							1
25–27								1								1
22–24										1						1
19–21								1		1	1	2	2			7
16–18										2						2
13–15					1		1		1	1		2		1		7
7–9							1	1	1			1				4
4–6							3	2	2						1	8
1–3	1	1	3	4		2	1				1	1	1			15
Totals.	1	1	3	4	1	2	6	5	5	5	2	6	3	1	1	46

Maximum delays obtained. Although there were relatively few cases in each experiment on which maximum delays were obtained, Pearsonian coefficients of correlation were computed to determine the extent of the relationships existing between these delays as obtained in the various experiments and each child's chronological and mental age, and intelligence quotient. Since in each experiment, the chronological age was available for all of the children but not their intelligence quotients, the distributions showing the scatter of the maximum delays obtained in relation to each child's chronological age are given in tables 21, 22, 23, and 24. Apart from a consideration of the distribution of the cases, the coefficients are of little value, because the items are so unevenly apportioned.

The scatter diagram for the relationship between chronological age and the maximum delays in the first experiment is given in table 21.

The delays were divided into three day groups, but only those in which maximum delays occurred are given in table 21. None of the children under three years of age remembered the position of the concealed object after delays of more than three days. There were, also, a few children over three years who did not remember where to obtain the reward longer than three days, and some who did not make correct responses after delays over nine days in duration. The failure of an older child to respond correctly after delays of less than ten days was due in individual cases to such factors as poor attention, excitability, inability to combat the perseverative effect of previous responses, as well as poor "memory," if such it may be called.

There are duplicate entries for four of the children who obtained maximum delays in each of the two years that this experiment was given. These children were numbers 21, 32, 34, and 45. In each case there was an increase in the maximum delay obtained. This fact, as well as the relationship shown between increasing age and the maximum delays obtained, indicates that chronological age is an important factor in the ability to respond to an absent stimulus of this kind, after varying periods of delay. In the correlations given later, the chronological and mental ages are presented in relation to the maximum delays obtained for the two years, but the intelligence quotients are only correlated with the last delay obtained.

The distribution of the maximum delays obtained in the second experiment with the familiar forms used as stimuli, in relation to chronological age is given in table 22.

The distribution in this table indicates a more rectilinear relationship than that portrayed in table 21. Although the obtaining of maximum delays in this experiment was not very satisfactory, those that were obtained show a very close relationship to the child's chronological age. The limited number of cases included, however, permit of only a general statement, that the older children tend, on the whole, to remember a familiar form

seen longer than the younger children. With additional numbers the distribution would very probably be considerably different.

Although the experiment with the geometric forms was the most adequately tried out, and the delays the most certainly determined, table 23 indicates the absence of any relationship beween chronological age and the maximum delays obtained.

TABLE 22

The distribution of maximum delays and chronological ages in Experiment II

MAXIMUM DELAY	CHRONOLOGICAL AGE IN MONTHS									TOTAL NUMBER
	33–35	36–38	39–41	42–44	45–47	48–50	51–53	54–56	57–59	
days										
34–36									1	1
19–21				1		2			1	4
16–18						1		2	1	4
13–15							2			2
10–12				1	1					2
7–9								1		1
1–3	2									2
Totals...	2			2	1	3	2	3	3	16

TABLE 23

The distribution of maximum delays and chronological ages in Experiment III

LENGTH OF MAXIMUM DELAY	CHRONOLOGICAL AGE IN MONTHS										TOTAL NUMBER
	42–44	45–47	48–50	51–53	54–56	57–59	60–62	63–65	66–68	69–71	
4 days					1	2					3
2 days	1		2	1		1	1	1	1	1	9
1 day			3	2	1	1		1			8
0–6 hours		3		3		2		1		1	10
Totals.....	1	3	5	6	2	6	1	3	1	2	30

On the basis of this distribution it would be difficult to predict any child's possible maximum delay when his chronological age was given. If this experiment had introduced a training series that would have enabled the younger children to participate in this experiment, it is very probable that the relationship would have appeared somewhat closer than it does for these children in

the older age ranges. So many factors influence the delayed response aside from the memory for the forms seen that it is impossible, without further investigation, to give any adequate explanation of the great scatter in the distributions.

The experiment with the unfamiliar forms was the least completely carried out of any of the experiments, primarily because it was formulated after the results on the previous experiments pointed the way to the institution of a more difficult situation, near the end of the experimental period. The distribution of the maximum delays obtained in relation to the chronological age is given in table 24.

This table indicates the absence of any relationship between chronological age and the delays obtained using unfamiliar forms as

TABLE 24

The distribution of maximum delays and chronological ages in Experiment IV

LENGTH OF MAXIMUM DELAY	CHRONOLOGICAL AGE IN MONTHS								TOTAL NUMBER
	48–50	51–53	54–56	57–59	60–62	63–65	66–68	69–71	
2 days								1	1
1 day	2	1	1	1	1		1		7
0–6 hours	2	2		2		2		1	9
Totals....	4	3	1	3	1	2	1	2	17

the stimuli. The two oldest children in the group had maximum delays which fall in the highest and lowest classes respectively. The determination of the delays was not certainly established except in the cases of those below six hours, where more trials could be given to the same child. In spite of the nature of this distribution, it is very probable that more accurately determined delays would show a closer relationship to chronological age than is indicated by that given in table 24.

Even though a limited number of cases were included in the four experiments, coefficients of correlation were computed to discover the nature of any relationships that might exist among the delays obtained in the various experiments and certain other factors. Since the delays were very limited in their magnitude,

and so many cases occurred in each group, it was impractical to use the rank order method of correlation. The Pearsonian coefficients of correlation and their probable errors as presented in table 25 were obtained from the following formulae.

$$r = \frac{\frac{\Sigma\, xy}{N} - cx \cdot cy}{\sigma x \cdot \sigma y}$$

$$P.E. = .6745 \cdot \frac{1 - r^2}{\sqrt{N}}$$

Where, r = coefficient of correlation
x and y are the variates
cx and cy are the corrections for an arbitrary origin
σ = standard deviation
N = number of cases
$P.E.$ = probable error
Σ = sum of

TABLE 25

Correlations obtained between the maximum delays obtained by the children in the four experiments and their C.A.'s, M.A.'s and I.Q.'s

EXPERIMENT	CHRONOLOGICAL AGE			MENTAL AGE			INTELLIGENCE QUOTIENT		
	Number of cases	r	P.E.	Number of cases	r	P.E.	Number of cases	r	P.E.
I	46	+.478	.077	36	+.356	.098	32	+.212	.114
II	16	+.669	.093	13	+.751	.082	13	+.712	.092
III	30	+.134	.121	27	+.104	.128	27	−.271	.120
IV	17	+.185	.158	17	+.322	.147	17	+.312	.148

Since an unequal number of cases was used in finding the coefficients, this is also included for each case. The data presented in table 21, 22, 23, and 24 are the distributions on which the correlations for chronological age and the maximum delays are based. A somewhat questionable procedure was adopted with regard to determining the mental age used in these correlations. It was assumed that the intelligence quotient of a child remains constant, at least relatively so, and that although these intelli-

gence tests were given perhaps a month before or after the maximum delay was obtained, that if the chronological age at the time the child was stimulated for the trial on which the maximum delay was obtained was multiplied by his I.Q., there would be a limited amount of error in the mental age computed.

The correlations indicate that chronological age is the most important factor, on the whole, in determining the length of the maximum delay. Mental age is of more importance than the I.Q. in all of the experiments. The test using the familiar forms as stimuli shows the closest relationship to chronological and mental age and intelligence quotient in the maximum delays obtained. In this experiment, there was an insufficient number of cases to render this coefficient of any great value, except as an indication of a trend. The high correlation obtained for I.Q. and the maximum delay in this situation was due to the fact that the oldest children in this case had the highest I.Q.'s and hence the highest maximum delays.

Chronological age plays an unimportant rôle in determining the maximum delays in the experiments using geometric and unfamiliar forms as stimuli. The only negative coefficient obtained was between the maximum delay and the I.Q., using the geometric forms as stimuli. There was little relationship observed in the scatter diagram between these two factors, but the negative element was introduced largely by one case which had the highest I.Q. and whose maximum delay fell in the lowest class interval. Mental age appears to be a more important factor in the maximum delay in the experiment with unfamiliar forms than any of the other factors, but this correlation is too low and the probable error too high for it to be of any significance.

In case maximum delays were obtained in two or more experiments by the same child, these were used as the basis for determining the relationship existing between the tests. The coefficients and their probable errors are presented in table 26.

The number of cases in these coefficients of correlation are necessarily even more limited than where only the delays in one experiment were concerned. The only correlations indicating the existence of any relationship at all are those between

the delays obtained with concealed objects and familiar forms, concealed objects and unfamiliar forms, geometric and unfamiliar forms used as the stimuli. The others are of no significance except to indicate the absence of any relationship.

Very little weight can be attached to these coefficients either negatively or positively. Their smallness may be due to inadequate measures of the maximum delay, to a discrepancy between these factors and the maximum delay, or to both. It is certain that memory, as measured by these tests, is not any unit factor, but is dependent upon many conditions which may or may not be closely related.

No mention has been made throughout this study of the part played by sex in the ability to make delayed responses. Due to

TABLE 26

Correlations between the maximum delays obtained by the same children in the four experiments

EXPERIMENT	II			III			IV		
	Number of cases	r	P.E.	Number of cases	r	P.E.	Number of cases	r	P.E.
I	16	+.493	.128	17	−.252	.153	7	+.540	.181
II				13	+.122	.185	5	.000	.000
III							17	+.504	.122

the difficulty with which the subjects could be secured, no attempt was made to select an equal number of girls and boys, either for the groups as a whole or at each age. Any comparisons made between the sexes or any further discussion of age differences in the maximum delays obtained in this study would be premature, not only because of the unequal numbers in each age and sex group, but because the results are of a tentative nature and primarily indicative of the applicability of these tests for measuring the delayed responses of young children.

III. SUMMARY

In this summary, an attempt will be made to review the primary results of the experiments, to discuss the interrelationships

existing, and to point out problems suggested by this study of the delayed response.

The situation testing memory for the position where an object was concealed proved to be an excellent test for the younger children, and for measuring the ability of the older children to make a correct response to an absent stimulus after long periods of delay. The maximum delays obtained in this experiment ranged from 1 to 34 days. The older children and those with the higher mental ages tended to remember longer than the younger children or those with the lower mental ages. Although this was valuable as a test of the length of time that a given stimulus could be responded to accurately after a given delay, it did not permit of any measurable variations due to the long delays obtained. The children's behavior and vocal responses offered some cues as to the manner in which the positions were remembered, and as to the nature of the relative effects of previous responses and the most recent stimulus upon the delayed response.

A marked perseverative effect of previous stimuli and responses when the familiar forms were employed was observed. This experiment, however, showed the closest relationship to the child's chronological and mental age. If the younger children were taught the method of response in this experiment, the test situation would provide an excellent means for measuring their delayed responses and the effect of variations in the stimuli. For the children who mastered the situation, the maximum delays varied from 1 to 34 days.

For the older children, either the geometric or unfamiliar forms are effective as stimuli in measuring the delayed response. The delays obtained were all below four days, and with certain limitations in the exposure and types of forms used, this maximum delay could perhaps be reduced to one day for the best reactors, and to several hours for a majority of the children. The importance of language responses in increasing the length of the delay after which a correct response would be made could very profitably be studied by the use of this method. The absence of any relationship between the maximum delays obtained in

these two tests and the chronological and mental age, and the I.Q.'s appears to be due to the complexity of the elements included in the situation, and to the limits used in determining the maximum delays. The responses to the two tests by the same child were very similar.

The field of measuring the delayed responses of young children is essentially a new one, and the development of methods of investigation was an important result of this study. From the experimental results obtained, it was readily determined that the children's ability to remember different sort of stimuli varied greatly. Modifications of the procedure, as well, provide great opportunity for measuring variations in the delayed response. It is very probable that if the child were permitted to hide the reward himself, or could expose the form in the tachistoscope, his delayed response would be very different from that observed when this was performed by the experimenter. Changes in the exposure time, varying from the least time in which the stimulus could possiby be seen, to 30 seconds or more, when the child would have become thoroughly bored with the situation, would probably give different types of delayed responses. Accessory stimulation such as telling the child to remember, promising additional rewards for success, permitting the child to make a response immediately after the occurrence of the stimulus merits study. In order to investigate further, the effects of unequal familiarity and associative values of the forms upon the delayed response, control experiments should be planned.

There is a question as to the perseverative effect which might occur in case two types of stimuli were used alternately in a series, for instance one of six geometric forms in one trial, and one of six others in the succeeding trial, then one of the first group, and so on, that might well be studied. Perhaps this method could be used instead of more widely spaced trials. The selection of forms in this case, however, necessitates a separate investigation in itself.

Grouping trials very closely together and testing the perseverative effects manifested without regard to the establishment of a maximum delay might be carried out in order to study the con-

flicting results of a recent stimulus and the earlier responses. The order of the trial series permits of much variation, as well. The younger children should be given a training series, enabling the use of multiple choice situations with them before this method is employed at two to three years.

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